NIST HANDBOOK 146, Volume I

Software User's Guide for the HAZARD I Fire Hazard Assessment Method

Version 1.1

Richard D. Peacock
Walter W. Jones
Richard W. Bukowski
C. Lynn Forney

United States Department of Commerce
National Institute of Standards and Technology

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Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

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U.S. Department of Commerce
Robert A. Mosbacher, Secretary

National Institute of Standards and Technology
John W. Lyons, Director

DISCLAIMER

The Department of Commerce makes no warranty, express or implied, to users of the HAZARD I Fire Hazard Assessment Method and associated computer programs, and accepts no responsibility for its use. Users of HAZARD I assume sole responsibility under Federal and State law for determining the appropriateness of its use in any particular application; for any conclusions drawn from the results of its use; and for any actions taken or not taken as a result of analyses performed using HAZARD I.

Users are warned that HAZARD I is intended for use only by persons competent in the field of fire safety and is intended only to supplement the informed judgment of the qualified user. The HAZARD I software package, used outside of the broader HAZARD I Fire Hazard Assessment Method, is a computer model which may or may not have predictive value when applied to a specific set of factual circumstances and which could lead to erroneous conclusions if not properly evaluated by an informed user.

INTENT AND USE

The algorithms, procedures, and computer programs described in this report constitute a prototype version of a methodology for predicting the consequences to the occupants of a building resulting from the involvement of particular products in a specified fire. They have been compiled from the best knowledge and understanding currently available, but have important limitations which must be understood and considered by the user. The hazard analysis method is intended for use by persons competent in the field of fire safety, and with some familiarity with personal computers. It is intended as a decision-making tool, but the scope of its use is exploratory.

Acknowledgments

FAST_in, FAST, FASTplot, EXITT, and TENAB are written in FORTRAN 77 and compiled with Lahey Computer Systems F77L® FORTRAN compiler[1]. The HAZARD I Interface Shell, MLTFUEL, and DETACT are written in Microsoft QuickBasic® with extensions using QuickPak Professional® from Crescent Software. Graphics capabilities in FAST and FASTplot were developed with MetaWindows® from Metagraphics Software Corporation. The METAPRNT utility for printing graphics is copyrighted and provided under license from Metagraphics Software Corporation. METAPRNT is provided to you for the exclusive use with HAZARD I. FIREDATA was written in DBase III® and compiled with the Clipper® Dbase compiler. The installation program used to install HAZARD I, *INSTALL*, is licensed software provided by Knowledge Dynamics Corporation. *INSTALL* is Copyright® 1987-1989 by Knowledge Dynamics Corporation which reserves all copyright protection worldwide. *INSTALL* is provided to you for the exclusive purpose of installing HAZARD I.

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[1] The use of company names or trade names within this report is made only for the purpose of identifying those computer hardware or software products with which the compatibility of the programs of HAZARD I has been tested. Such use does not constitute any endorsement of those products by the National Institute of Standards and Technology.

CONTENTS Page

1 Overview	1
1.1 The Need for Quantitative Hazard Analysis	2
1.2 Overall Approach	5
1.3 What's New in HAZARD I	6
1.4 A Guide to the Documentation	8
1.4.1 Technical Reference Guide for HAZARD, Version 1.1 . .	11
1.4.2 Software User's Guide for HAZARD, Version 1.1	13
1.5 Learning HAZARD I	14
1.6 Assumptions and Limitations	15
1.6.1 Scope Limitations	16
1.6.2 Programs and Procedures Limitations	16
1.6.3 Specified Fire Limitations	17
1.6.4 Transport Limitations	19
1.6.5 Occupant Behavior and Evacuation Limitations	22
1.6.6 Activation of Thermal Devices Limitations	22
1.6.7 Tenability Criteria Limitations	23
2 Getting Started	25
2.1 Protecting Your Original Disks	25
2.2 Installing HAZARD I on Your Computer	26
2.2.1 Customizing the Installation	30
2.3 Running HAZARD I	34
3 Learning	57
3.1 Organizing Data Files in HAZARD I	57
3.1.1 Naming Files	57
3.1.2 Data Subdirectories	59
3.2 The Example Case	59
3.3 Defining the Context	59
3.4 Defining the Scenario(s) of Concern	60
3.5 Calculating the Hazard	60
3.5.1 FIREDATA	61

FIGURES

TABLES

For technical support on the HAZARD I software, contact

Fire Hazard Analysis
Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

R. W. Bukowski (301) 975-6853
R. D. Peacock (301) 975-6664
W. W. Jones (301) 975-6887

1 Overview

In June 1989, the Center for Fire Research at the National Institute of Standards and Technology released a method for quantifying the hazards to occupants of buildings from fires, and the relative contribution of specific products (e.g., furniture, wire insulation) to those hazards [1], [2]. The culmination of six years of development this method, called HAZARD I, was the first such comprehensive application of fire modeling in the world. It combined expert judgment and calculations to estimate the consequences of a specified fire. These procedures involve four steps: 1) defining the context, 2) defining the scenario, 3) calculating the hazard, and 4) evaluating the consequences. Steps 1, 2, and 4 are largely judgmental and depend on the expertise of the user. Step 3, which involves use of the extensive computer software, requires considerable expertise in fire safety practice. The heart of HAZARD I is a sequence of computer software procedures which calculate the development of hazardous conditions over time, calculate the time needed by building occupants to escape under those conditions, and estimate the resulting loss of life based on assumed occupant behavior and tenability criteria.

The first version can model up to six rooms on multiple floors of a building, but data against which its results have been compared are only available for structures of the general dimensions of single-family homes. The method guides the user to identify the fire problems of concern and then to specify representative fire scenarios. The user then employs a computer software package to predict the outcome of each of the identified scenarios in considerable detail. The software predicts over time, the temperature, smoke, and fire gas concentrations in each room of the building, the behavior and movement of the building occupants as they interact with the fire, the building, and each other, and the impact of exposure of each occupant to the fire-generated environment. The occupant exposures are presented as a prediction of successful escape, physical incapacitation or death along with the time, location, and cause. By accounting for the interactions of a large array of factors on the result of a given fire situation, the method enables the user to analyze the impact of changes in the

fire performance of products, building design and arrangement, or the inherent capabilities of occupants on the likely outcome of fires. With such information it should be possible to provide better, more cost-effective strategies for reducing fire losses.

This report marks the first major revision to the original document. In addition to improvements to the documentation, a number of new physical phenomena and features have been added to the software which accompanies the methodology. Constructive feedback from its use will better define its usefulness and limitations and will help to foster needed improvements. Users should exercise sound technical judgment in applying the algorithms and computer programs described herein.

1.1 The Need for Quantitative Hazard Analysis

Public fire safety is provided through a system of fire and building codes which are based on the judgment of experts in the field, and which incorporate test methods to measure the fire properties or performance of materials and products. These codes generally prescribe the construction methods and materials considered acceptable in various classes of occupancy, which are defined on the basis of use and the assumed capabilities of the users. They rely heavily on the concepts of compartmentation and the provision of duplicate, protected paths of egress. A number of active fire protection systems are also required, including various combinations of detection/alarm, suppression, and smoke control/management systems. These systems work together with the passive measures to provide additional time for safe evacuation of the affected area and reduction of the fire impact on the structure and its occupants.

This system of fire and building codes works to provide a reasonable level of safety to the public. However, existing codes need continual revision as new materials or design and construction techniques are introduced. Quantitative tools for fire hazard analyses can provide the code official with ways of addressing such developments consistent with the intent of the code. The flexibility provided by these quantitative tools can help to ensure the safe and

rapid introduction of new technology by providing information on the likely impact on fire safety before a performance record is established through use. Similarly, these methods can be of value to product manufacturers in identifying the potential fire safety benefits of proposed design changes.

There are many highly interactive factors which need to be considered in performing a quantitative fire hazard analysis (see Figure 1). Experimental measurements of the burning behavior of materials of interest and details of the building in which they burn are needed to define the fire in terms of its release of energy and mass over time. The transport of this energy and mass through the building is influenced by its geometry, the construction materials used, and the fire protection systems employed. The response of occupants and the consequences of the fire depend on when the occupants are notified, their physical capabilities, the decisions they make, and their susceptibility to the hazards to which they are exposed.

Tools for fire hazard analysis make it possible to evaluate product fire performance against a fire safety goal. For example, a goal of fire safety has always been to "keep the fire contained until the people can get out." The problem is that it is very difficult to keep the "smoke" contained. Quantitative hazard analysis allows the determination of the impacts of smoke, such as toxicity, *relative* to the impact of other hazards of fire for a prescribed building and set of occupants. It determines if the time available for egress is greater than the time required; and if not, why not. Time is the critical factor. Having 3 minutes for safe escape when 10 are needed results in human disaster. But providing 30 minutes of protection when 10 are needed can lead to high costs. A hazard analysis method can help prevent both types of problems from occurring.

Quantitative hazard analysis techniques have the potential of providing significant cost savings. Alternative protection strategies can be studied within the hazard analysis framework to give the benefit-cost relation for each. In addition, measures are evaluated as a system with their many interactions, including the impact of both structure and contents. Providing these alternatives promotes the design flexibility which reduces redundancies and cost without
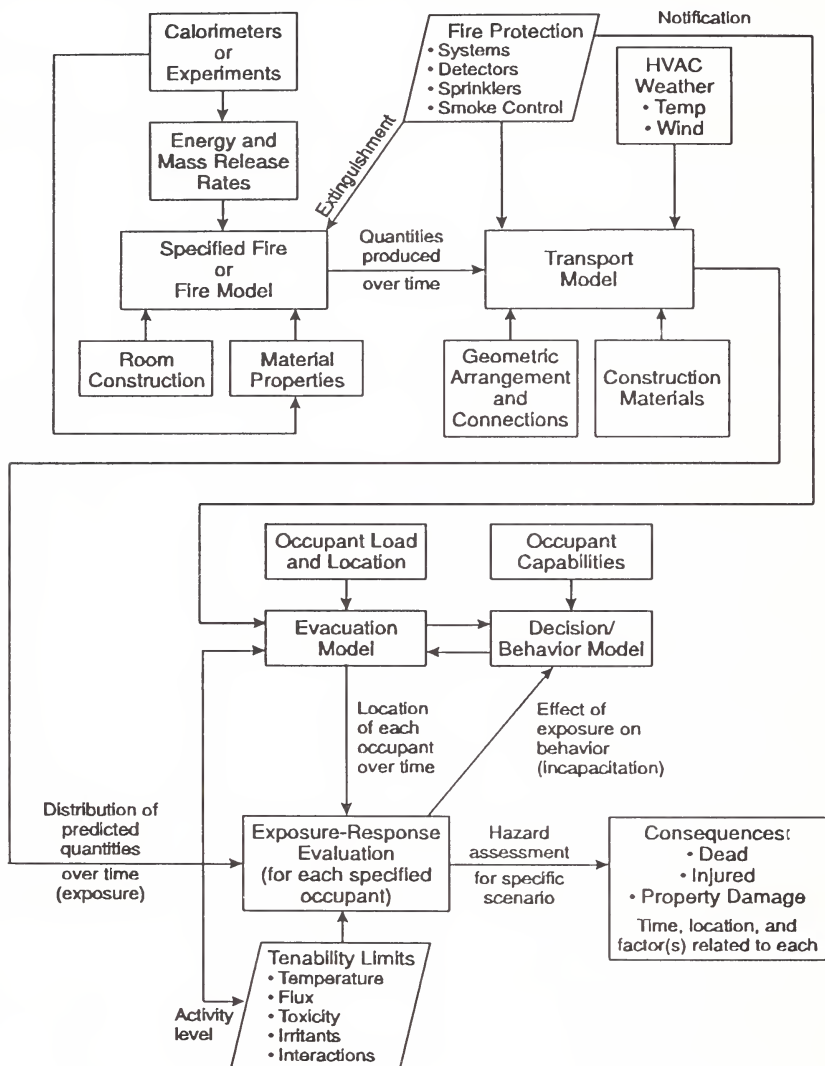
Figure 1. Interrelationships of major components of a fire hazard model.

sacrificing safety. New technology can be evaluated before it is brought into practice, thus reducing the time lag currently required for code acceptance. Thus, quantitative hazard analysis is a powerful complement to existing codes and standards and a useful tool in evaluating improvements to them.

1.2 Overall Approach

HAZARD I is a set of procedures combining expert judgment and calculations to estimate the consequences of a specified fire. These procedures involve four steps: 1) defining the context (the broad range of applications for a chosen product or products), 2) defining the scenario (the specific cases to be studied), 3) calculating the hazard, and 4) evaluating the consequences. Steps 1, 2, and 4 are largely judgmental and depend on the expertise of the user. Step 3, which involves use of the extensive HAZARD I software, requires considerable expertise in fire safety practice. The heart of HAZARD I is a sequence of procedures implemented in computer software to calculate the development of hazardous conditions over time, calculate the time needed by building occupants to escape under those conditions, and estimate the resulting loss of life based on assumed occupant behavior and tenability criteria. These calculations are performed for specified buildings and fire scenarios of concern.

The buildings and scenarios of interest to the user of a fire hazard assessment will depend on the purpose of the assessment. For example, product manu-facturers would be more interested in all scenarios involving their products than in scenarios in a specific building. The interest of fire investigators will be with specific fires in specific buildings, since they are reconstructing incidents which have occurred.

A set of reference examples has been compiled to assist the user through the process, and to demonstrate the capabilities of the procedure. These include sets of prototypical residential buildings and common fire scenarios. The method described in this report allows the user to substitute his product for that in one of the examples using one of the prototypical buildings or scenarios, or perform

an analysis on a different building or scenario provided, of course, that the phenomena involved are not beyond the technical capabilities of the models.

Not every situation merits a complete or new set of hazard calculations. For example, users may find that their questions can be answered simply by estimating or inferring the expected performance of their product from review of the provided matrix of preworked examples. Obviously, over time as the number of preworked examples increases, many users will find the results they need simply by looking up estimated performance from such files. Alternatively, potential users of HAZARD I may find that their concerns involve situations beyond the current capabilities of the system, in which case he must revert to traditional approaches, i.e., some combination of experience, judgment and/or small- or full-scale fire tests. The third alternative is that the users choose to run through a complete set of new calculations for their problem situation. The flow chart, Figure 2, illustrates these three alternatives for the potential user of HAZARD I.

1.3 What's New in HAZARD I

Much of the content of this incremental upgrade to HAZARD is the same as the original release version. Details of the content of the new version is shown below. The following summarizes the changes from the original version of HAZARD I released in August of 1989.

- New in FAST: New physical phenomena were added — forced ventilation (see section 7.3.5.6 of the Technical Reference Guide) and deposition of hydrogen chloride on material surfaces (section 7.3.5.6 of the Technical Reference Guide). A more general chemistry scheme is included which allows for oxygen and chlorine in the fuel (section 7.5.3.5 of the Technical Reference Guide). The limitation on entrainment, applicable to small fires in large spaces, has been changed. Section 7.3.5.3 of the Technical Reference Guide provides details of the entrainment model used in FAST. There have also been a series of improvements and fixes in the FAST-related software.

Step 1

Define Product and
Context of Use

Check System Limits

Measure Product
Properties
Cone calorimeter
Furniture calorimeter
Full room burn

Check Statistics

Check if Example
Scenarios Applicable

Define Scenarios

Step 2

Substitute Product
for that in Example

Input Data
from Data Base

Step 3

Run Programs
Transport, detection,
decision and action

Use Judgment
Based on Test Data,
Experience and
Current Use

Evaluate
Consequences
Compared with
Examples

Evaluate
Consequences
(adequate time to
escape)

Step 4

Figure 2. The overall method.

- The new documentation is divided into two volumes, a "Technical Reference Guide," (TRG) and a "Software Users Guide" (SUG). To centralize the discussion of examples of using HAZARD, the TRG includes a number of examples of cases in addition to those originally in the Example Cases volume of HAZARD I. The SUG was updated and expanded to describe new phenomena in the model, new operation for the building egress model EXITT, and improvements in the user interface.

- New versions of the sub-models of HAZARD I. Version 18.5 of FAST is the core of the software package. New versions of FAST_in, FASTplot, EXITT, TENAB, and the HAZARD shell are also included, with changes to support the new version of FAST.

- The EXITT input file is organized for easier data entry — the problem encountered most frequently by those who used the entire hazard prediction was creating EXITT's building files. With a new data structure and a detailed example in the manual, this problem should be significantly reduced.

1.4 A Guide to the Documentation

This section provides an overview of the documentation and a guide to help the user efficiently learn of the capabilities (and limitations) of the methodology and accompanying software.

The set of computer disks contains the software necessary to conduct hazard analyses of products used in residential occupancies. All of the software provided will operate on any IBM PC (XT, AT, or PS/2) or compatible MS-DOS computer with the following minimum hardware configuration:

- 640 k memory
- graphics card (IBM CGA, EGA, or VGA; or Hercules compatible)

- hard disk drive (about 2 Mb required for the files)
- math co-processor (8087, 80287, OR 80387)
- MS-DOS 3.0 or higher

The organization of the HAZARD I software package is shown in Figure 3. It includes a number of software modules (shown in the figure enclosed in rectangles) which implement the calculations necessary to conduct a hazard analysis:

- an interactive, user interface program for entering data into the fire model (FAST_in);

- a database program (FIREDATA) including files of thermophysical, thermochemical, and reference toxicity data;

- the FAST model (version 18.5) for multi-compartment energy and mass transport;

- a graphics utility for plotting data (FASTplot);

- a detector/sprinkler activation model (DETACT);

- an evacuation model which includes human decision/behavior (EXITT); and

- a tenability model (TENAB) which makes determinations for both incapacitation and lethality from temperature and toxicity, along with potential incapacitation from burns due to flux exposure.

This HAZARD I Software User's Guide includes detailed instructions for the use of the software, the form of the data provided to each of the modules, and examples of the use of the software.

A set of representative example cases of typical residential fires, established by two panels of outside experts, is also included in the documentation. Details of
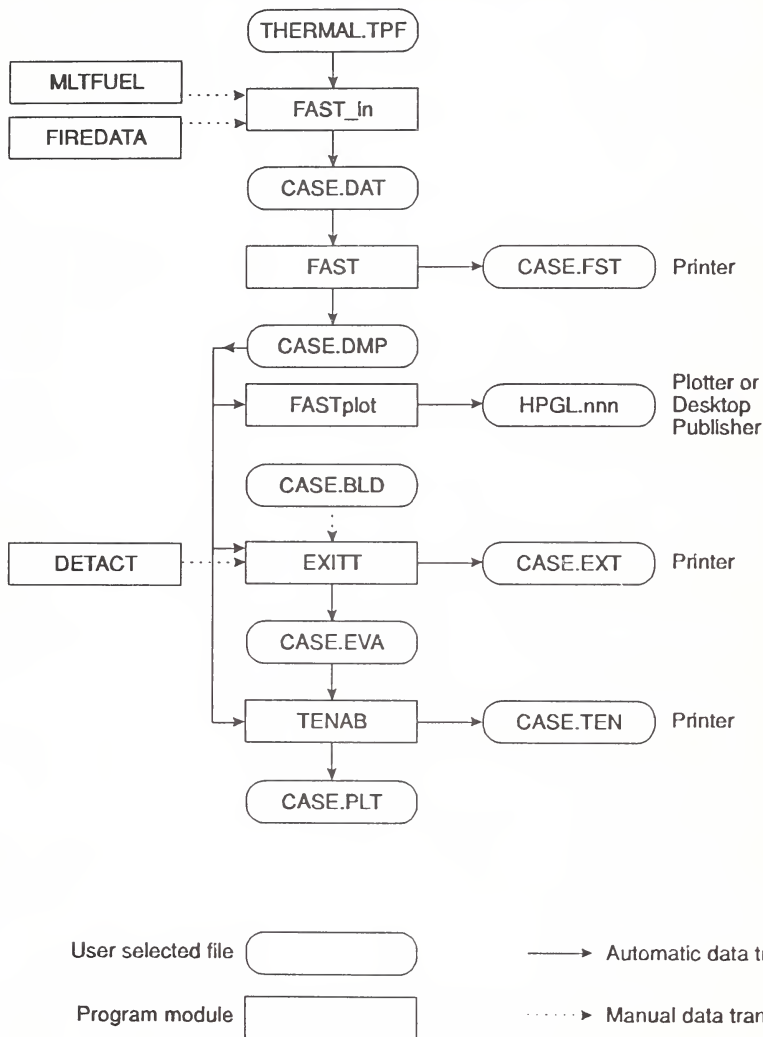
Figure 3. HAZARD I software.

the fires were specified by a panel composed of representatives of the major fire service organizations. The three single-family residences were verified as representing typical homes by a panel from the model code and architectural communities. A description of the process of developing these cases and a complete set of the output produced from one of these cases (input data file listings, program outputs and graphs of selected variables) are provided in section 8 of the Technical Reference Guide.

While the scope of this first hazard assessment method is limited to residential occupancies, our goal is to extend it to other occupancy classes. Such an extension would be made in parallel with the improvements identified through user feedback.

1.4.1 Technical Reference Guide for HAZARD, Version 1.1

This Technical Reference Guide provides a detailed description of the methodology and its application in HAZARD I.

Overview describes, in very general terms the approach to hazard analysis in HAZARD I. Sections are included to highlight new features and to guide readers through the documentation.

Background provides a historical perspective of fire hazard analysis leading up to HAZARD I. This section has been updated to the present with discussion of the original HAZARD I release and some applications published to date.

Step-by-Step Procedure describes the procedure for hazard analysis using HAZARD I.

Fire Incident Data is a summary of fire statistics which can be used to develop input data for HAZARD I.

Calculational Procedures provides the user with engineering tools which may be used to develop input data for the hazard prediction. Three topics are currently covered: "Determining the rate of heat release," "Adjusting the combustion chemistry," and "Ignition of the second item."

Tenability Limits discusses the background information used to determine appropriate tenability criteria.

Program Modules presents the theory and assumptions inherent in the models and programs of HAZARD I. This section has been greatly expanded by incorporating the theoretical sections of the Appendices B (FAST), C (EXITT), and D (DETACT) of the original HAZARD I release.

Example Cases In addition to the discussions from the original Technical Reference Guide, we have added more examples to illustrate new features (such as mechanical ventilation). The examples from the original Example Cases volume of the original HAZARD I release will be incorporated into this section — but not all in the same level of detail included in the original. Although we have included more examples for the new documentation, only a single example is presented in the full, detailed format included in the original release. For the remaining examples, a scenario description and the model inputs are presented. A single, printed output will be provided for comparison with results calculated on the user's computer.

Concluding Remarks has been enhanced with discussion of some of the experience gained with HAZARD I.

1.4.2 Software User's Guide for HAZARD, Version 1.1

The Software User's Guide provides the user with detailed instruction for the use of the software included as part of HAZARD I. In addition to a detailed reference to all software modules, a learning guide which performs an investigation of a single scenario from initial scenario description to tenability analysis is included.

Overview is identical to the overview in the TRG.

Getting Started provides a keystroke-by-keystroke guide to starting the learning process with the HAZARD I software. We have included new information on installation of the software. We used a commercial package for software installation which should save time and effort in installation.

Learning continues the process of working a single example from start to finish, but without the keystroke-by-keystroke minutia provided in the Getting Started section. It has been expanded to include the development of a building file for EXITT using a worksheet to keep the information organized. Extra worksheets are provided in the back of the manual.

Reference gives complete details of all the inputs and outputs of all the modules. We have updated the EXITT, FAST, and FAST_in sections to reflect the new software.

Error Messages provides an English description of the common error messages encountered with the HAZARD software. This section received only minor updating.

1.5 Learning HAZARD I

Clearly, without some plan of attack, the amount of printed material included as part of HAZARD I is imposing. While some of the material is included mainly for reference purposes, much of the material is required for the effective use the hazard methodology. This section provides one possible strategy to guide one through the documentation.

1.   Read this "Overview" section of the Technical Reference Guide. It provides a general description of the hazard methodology and the accompanying software along with a summary of the limitations of the implementation in HAZARD I.

2.   Section 3 of the Technical Reference Guide, "Step-by-Step Procedure for Conducting a Hazard Analysis" will introduce the reader to the details of conducting a hazard analysis with HAZARD I.

3.   Sections 2 and 3 of the Software User's Guide will allow the user to conduct a complete hazard analysis using HAZARD I for a single scenario.

4.   Sections 5 and 6 of the Technical Reference Guide describe details of developing the necessary data for a hazard analysis. The examples in section 8 of the Technical Reference Guide can be used to develop other scenarios of interest to the reader. Section 7 of the Technical Reference Guide provides the detailed theoretical background of the calculations performed by each program modules in the HAZARD I software. Section 4 of the Software User's Guide details all of the inputs for these program modules.

1.6 Assumptions and Limitations

The HAZARD I software consists of a collection of data, procedures, and computer programs which are used to *simulate* the important time-dependent phenomena involved in residential fires. The major functions provided include calculation of:

- the production of energy and mass (smoke and gases) by one or more burning objects in one room, based on small- or large-scale measurements,

- the buoyancy-driven transport of this energy and mass through a series of user-specified rooms and connections (e.g., doors, windows, cracks),

- the resulting temperatures, smoke optical densities, and gas concentrations after accounting for heat transfer to surfaces and dilution by mixing with clean air,

- the evacuation process of a user-specified set of occupants accounting for delays in notification, decision making, behavioral interactions, and inherent capabilities, and

- the impact of the exposure of these occupants to the predicted room environments as they move through the building, in terms of the expected fatalities, and the time, location, and cause of each.

As can be seen from this list, the hazard analysis involves an interdisciplinary consideration of physics, chemistry, fluid mechanics, heat transfer, biology, toxicology, and human behavior. In some areas, fundamental laws (conservation of mass, energy, and momentum) can be used, whereas in others empirical correlations or even "educated guesses" must be employed to bridge gaps in existing knowledge. The necessary approximations required by operational practicality result in the introduction of uncertainties in the results. The user should understand the inherent assumptions and limitations of the procedures and

programs, and use these programs judiciously - including sensitivity analyses for the ranges of values for key parameters - in order to make estimates of these uncertainties. This section provides an overview of these assumptions and limitations. A more detailed discussion is included in section 7 of the Technical Reference Guide.

1.6.1 Scope Limitations

Since the majority of U.S. fire losses are in one- and two-family residential structures, this occupancy was selected for the first hazard system. The scope will be broadened in future versions of the system. The scope of HAZARD I has been limited to one- and two-family residential structures. Models of the complex flows of heat and smoke through the HVAC systems and up the tall stairwells found in other occupancies are not yet sufficiently refined to include them in HAZARD I. Similarly, the focus has been on the inclusion of "rules" for the behavioral interactions of people within family units in the EXITT model. Large-building evacuation models, which include phenomena such as congestion in and around stairwells and behaviors typical of people in other occupancies, have not yet been incorporated into HAZARD I.

1.6.2 Programs and Procedures Limitations

Figure 3 presents the HAZARD I software package developed to implement the assessment of hazard. Of the eight programs shown, three (FIREDATA, FAST_in, and FASTplot) perform utility and user interface functions only.

The principal current limitation of FIREDATA is that data are provided for only a small set of example products. Data provided in the cone and furniture calorimeter files are measured values from individual samples tested in these devices under a specified set of conditions. While the materials are identified generically, it should be understood that such data are not necessarily representative of the behavior of all materials that fall within that generic category. Some variation would be expected, even on a set of samples from the same lot, and

no attempt was made to obtain representative samples for test, or to perform repeatability tests to evaluate experimental error. Also, data in the thermophysical properties file were taken either from manufacturers' data or from literature sources with no attempt to verify values or to determine if they are the most representative values. Finally, the data in the toxicity file are published values from the sources indicated. Only some of the sources provide confidence intervals for these data. The material identifications are those provided in the sources.

1.6.3 Specified Fire Limitations

An important limitation of HAZARD I is the absence of a fire growth model. At the present time, it is not practical to adapt currently available fire growth models for direct inclusion in HAZARD I. Therefore, the system utilizes a user specified fire, expressed in terms of time specified rates of energy and mass released by the burning item(s). Such data can be obtained by measurements taken in large- and small-scale calorimeters, or from room burns. Their associated limitations are as follows:

1.   For the Furniture Calorimeter, a product (e.g., chair, table, bookcase) is placed under a large collection hood and ignited by a 50 kW gas burner (simulating a wastebasket) placed adjacent to the item for 120 s. The combustion process then proceeds under assumed "free-burning" conditions, and the release rate data are measured. Potential sources of uncertainty here include measurement errors related to the instrumentation, and the degree to which "free-burning" conditions are not achieved (e.g., radiation from the gases under the hood or from the hood itself, and restrictions in the air entrained by the object causing locally reduced oxygen concentrations affecting the combustion chemistry). There are limited experimental data for upholstered furniture which suggest that prior to the onset of flashover in a compartment, the influence of the compartment on the burning behavior of the item is small. The differences obtained from the use of different types or

locations of ignition sources have not been explored. These factors are discussed in reference [3].

2. Where small-scale calorimeter data are used, procedures are provided to extrapolate to the behavior of a full-size item. These procedures are based on empirical correlations of data which exhibit significant scatter, thus limiting their accuracy. For example, for upholstered furniture, the peak heat release rates estimated by the "triangular approximation" method averaged 91% (range 46% to 103%) of values measured for a group of 26 chairs with noncombustible frames, but only 63% (range 46% to 83%) of values measured for a group of 11 chairs with combustible frames [4]. Also, the triangle neglects the "tails" of the curve; these are the initial time from ignition to significant burning of the item, and the region of burning of the combustible frame, after the fabric and filler are consumed.

3. The provided data and procedures relate directly only to burning of items initiated by relatively large flaming sources. Little data are currently available for release rates under smoldering combustion, or for the high external flux and low oxygen conditions characteristic of post-flashover burning which is currently considered the scenario in the United States where most deaths occur. While the program MLTFUEL allows multiple items burning simultaneously to be converted to a single "equivalent" specified fire, it does not account for the synergy of such mixtures. Thus, for other ignition scenarios, multiple items burning simultaneously (which exchange energy by radiation and convection), combustible interior finish, and post-flashover conditions, the provided procedures give estimates which are often nonconservative (the actual release rates would be *greater* than estimated). At present, the only sure way to account for all of these complex phenomena is to conduct a full-scale room burn and input the release rates to the transport model. Subsequent versions of the hazard system will include detailed combustion models such as those in HARVARD V [5] or FIRST [6] which can be used as the source fire.

1.6.4 Transport Limitations

The distribution of energy and mass throughout the rooms included in the simulation is done in the model FAST, which is a zone (or control volume) model. The basic assumption of such models is that each room can be divided into two or more zones, each of which is internally uniform in temperature and composition. In FAST, all rooms have two zones except the fire room, which has an additional zone for the fire plume. The boundary between the two layers in a room is called the interface.

It has generally been observed that in the spaces close to the fire, buoyantly stratified layers form. While in an experiment the temperature can be seen to vary within a given layer, these variations are small compared to the temperature difference between the layers.

Beyond the basic zone assumptions, the model typically involves a mixture of established theory (e.g., conservation equations), empirical correlations where there are data but no theory (e.g., flow and entrainment coefficients), and approximations where there are neither (e.g., post-flashover combustion chemistry) or where their effect is considered secondary compared to the "cost" of inclusion. An example of a widely used assumption is that the estimated error from ignoring the variation of the thermal properties of structural materials with temperature is small. While this information would be fairly simple to add to the computer code, data are scarce over a broad range of temperatures even for the most common materials.

With a highly complex model such as FAST, the only reasonable method of assessing impacts of assumptions and limitations is through the verification and validation process, which is ongoing at the Building and Fire Research Laboratory (BFRL). Until the results of this process are available, the user should be aware of the following:

1.   Within FAST, the user can elect to have burning constrained by the available oxygen. This "constrained fire" (type 2) is not subject to the influences of radiation to enhance its burning rate, but is influenced by

the oxygen available in the room. If a large mass loss rate is entered, the model will follow this input until there is insufficient oxygen available for that quantity of fuel to burn in the room. The unburned fuel (sometimes called excess pyrolyzate) is tracked as it flows out in the door jet, where it can entrain more oxygen. If this mixture is within the user-specified flammable range, it burns in the door plume. If not, it will be tracked throughout the building until it eventually collects as unburned fuel or burns in a vent. The energy released in the fire room and in each vent, as well as the total energy released, is detailed in the output of the model.

2.   An oxygen combustion chemistry scheme is employed only in constrained (type 2) fires. Here user-specified hydrocarbon ratios and species yields are used by the model to predict concentrations. A balance among hydrogen, carbon, and oxygen molecules is maintained. Under some conditions, low oxygen can change the combustion chemistry, with an attendant increase in the yields of products of incomplete combustion such as CO. Guidance is provided on how the user can adjust the CO/CO_2 ratio. However, not enough is known about these chemical processes to build this relationship into the model at the present time. Some data exist in reports of full-scale experiments (e.g., reference [7]) which can assist in making such determinations.

3.   The entrainment coefficients are empirically determined values. Small errors in these values will have a small effect on the fire plume or the flow in the plume of gases exiting the door of that room. In a multi-compartment model such as FAST, however, small errors in each door plume are multiplicative as the flow proceeds through many compartments, possibly resulting in a significant error in the furthest rooms. The data available from validation experiments [8] indicate that the values for entrainment coefficients currently used in most zone models produce good agreement for a three-compartment configuration. More data are needed for larger numbers of rooms to study this further.

4.   In real fires, smoke and gases are introduced into the lower layer of each room primarily due to mixing at connections between rooms and from the downward flows along walls (where contact with the wall cools the gas and reduces its buoyancy). Doorway mixing has been included in FAST, using an empirically derived mixing coefficient. However, for smoke flow along a wall, the associated theory is only now being developed and is not included in the model. This may produce an underestimate of the lower layer concentrations.

5.   In the present version of HAZARD I, energy (heat) gains in the lower layer result only from convective heating from the floor and lower walls. It is assumed that the lower layer does not absorb energy by radiation from the upper layer. This may produce an underestimate of the lower layer temperatures and an overestimate of the upper layer temperatures.

6.   The only mechanisms provided in zone models to move energy and mass into the upper layer of a room are two types of plumes; those formed by the burning item(s) in the fire room, and those formed by the jet of upper layer gases flowing through an opening. Thus, when the model calculates the flow of warm, lower layer gases through a low opening (e.g., the undercut of a door) by expansion, they are assigned to the lower layer of the room into which they flowed where they remain until the upper layer in the source room drops to the level of the undercut and the door jet forms. Thus, for a time the receiving room will show a lower layer temperature which exceeds that in the upper layer (a physically impossible condition). However, no hazard will exist during this time as the temperatures are low, and no gas species produced by the fire are carried through the opening until the upper layer drops to the height of the undercut.

1.6.5 Occupant Behavior and Evacuation Limitations

The EXITT model is a fairly-straightforward "node and arc" evacuation model to which an extensive series of behavioral rules has been added. The assumptions of interest are thus inherent in these rules, and the limitations are associated mostly with behavior not yet included. For example, the model does not have people re-entering the building, as they sometimes do. In addition, the current model is completely deterministic - a specific set of circumstances always results in a specific action. The data on which the rules were based sometimes identifies several potential actions (e.g., under this condition, 60% of the time they do A and 40% of the time they do B). To model such behavior properly, the program would have to employ probabilistic branching for a monte carlo type of simulation.

Within the current model, some of the rules are qualitative (e.g., a man's first action is to investigate) and some are quantitative (e.g., a woman between the ages of x and y walks at z m/s). The assumed values in quantitative rules are called parameter values, and the documentation for the model identifies each, the reason for assigning that value, and how the user can change it (allowing a sensitivity analysis to be performed on those parameters for which the user might feel that the supporting data are weak).

1.6.6 Activation of Thermal Devices Limitations

The activation of smoke detectors, heat detectors, or sprinklers is handled in the program DETACT. The underlying theory and assumptions used are described in the Technical Reference volume in the chapter on Program Modules. The basic assumption is one of quasi-steady ceiling layer gas flow under an unconfined ceiling (no walls). It is consistent with the experimental study [9], [10] done by Factory Mutual Research Corp. for the Fire Detection Institute (FDI) and on which the NFPA 72E [11] Appendix C methods were developed. As such, the assumptions employed in this program are those commonly used by the engineering and code communities and represent the current state-of-the-art. Smoke detectors are only crudely treated as heat

detectors with an activation temperature of 13 °C above ambient based on recommendations contained in the FDI study.

1.6.7 Tenability Criteria Limitations

The impact of exposure to the occupants is evaluated in the program TENAB. Individual determinations are made for both incapacitation and lethality from temperature and toxicity, along with potential incapacitation from burns due to flux exposure. No interactions between temperature and toxicity are currently included (e.g., it is assumed but not known whether temperature exposure changes the rate of uptake of toxic species or increases the susceptibility to toxic species). The basis for the threshold values used and the derivation of the equations on which the toxicity calculation is based are provided in the Technical Reference volume in the chapter on Tenability Limits, which contains an extensive list of references. For all cases except flux exposure, the user can easily change the limit values used (and is encouraged to do so as a sensitivity test). Also, the method of presentation of the output of TENAB facilitates the observation of the sensitivity of the result to the limiting value selected.

The limiting values of temperature exposure are based on the general literature, which includes some human data. The flux criterion comes from work done with pig skin, which is generally considered to be very similar to human skin. The toxicity data, however, are from the combustion toxicology literature which is based entirely on animal exposures (primarily rodents for lethality studies and nonhuman primates for incapacitation studies). The model assumes that humans will exhibit a similar physiological response.

A toxicity parameter, Ct (concentration multiplied by exposure time, often referred to as "exposure dose"), is used to indicate the toxic impact of the smoke without differentiating the constituent gases or the possibility of diminished oxygen. This is a broad assumption. Another toxicity parameter, the fractional exposure dose (FED), is also introduced. This represents the fraction of the lethal concentration that an individual has been exposed to over time. The FED parameter combines the effects and interactions of the gases

CO, CO_2, and HCN along with the effect of diminished oxygen. The model on which the FED calculation is based, referred to as the N-Gas model [12], is under continuing development, and additional gases will be added as the data are obtained. It is expected the first irritant gas (HCl) will be included in the next version.

2 Getting Started

This part of the manual provides a step-by-step introduction to the HAZARD I system. It describes how to install the HAZARD I software on your computer and start it and guides you through the modules of HAZARD I using a simple example. When you have completed this section, you should have accomplished the following:

- Installed HAZARD I on the hard disk of your computer system.

- Modified the system configuration files so that the software will operate properly in your selected colors and engineering units.

- Become familiar with the elements of the HAZARD I system.

Before beginning with the software installation, you should familiarize yourself with the layout of the manuals. Begin by scanning the table of contents of both volumes of HAZARD I to familiarize yourself with the content of the manuals. Section 1.5 provides one procedure for learning to use HAZARD I. You should become familiar with the "Overview" section (identical in both volumes) and the "Step-by-Step Procedure for Conducting a Hazard Analysis" section in the Technical Reference Guide before beginning installation of the software.

2.1 Protecting Your Original Disks

After installing the HAZARD I software on your computer system, you should place the original disks in a safe place in case the files should become corrupted or your hard disk fails. Since the software is never run from the floppy disks, it should not be necessary to make copies of the original disks.

2.2 Installing HAZARD I on Your Computer

An automatic installation program which prompts you for the necessary infor-
mation and copies the HAZARD I files onto your hard disk is included on the
distribution disks for HAZARD I. Since the programs which make up
HAZARD I are provided on the diskettes in compressed form (to save disk
space), you must use the automatic installation program to copy HAZARD I to
your hard disk. For those in need of specific custom installations for unique
hardware, several utility programs are provided to customize HAZARD I for
your system.

To install HAZARD I on your computer system, place the diskette labeled
"HAZARD I Installation Disk" into diskette drive A: and type the following
DOS commands

```
A:
INSTALL
```

You will be asked several questions about your computer system and how you
wish to install HAZARD I. You may answer none, some, or all of the
questions as appropriate for your specific needs. Follow the directions on the
screen closely and provide answers to questions as desired. Usually, the
defaults provided by the program will be sufficient. On several of the screens,
you will be asked to fill in information or change the defaults suggested by the
installation module if desired. These screens are described in more detail
below.

```
                        ┌─────────────┐
                        │  Drive C:   │
                        └─────────────┘




   On which disk drive do you wish to install HAZARD I:

   Use the [Up Arrow], [Down Arrow], [Page Up], and [Page Down] keys to
   move the bar to the disk drive you which to install to and then press
   the [Enter] key.
```

HAZARD I is installed in two subdirectories on your hard disk, one for the program files that comprise HAZARD I and one for data files. On the first three screens, you are asked to enter (or verify) the drive letter of your hard disk (usually C:), and the names of these two directories. For most installations, the defaults will be sufficient. However, for custom installations, any drive containing at least 3 megabytes of free space may be used any valid nonexisting directories may be used for the program and data directories.

```
       Reading: Library File --> SWU8CTB.PIC
     Verifying: SWU8CTB.PIC
 Decompressing: C:\HAZARDI\MLTFUEL.EXE
     Verifying: C:\HAZARDI\MLTFUEL.EXE
       Writing: C:\HAZARDI\DATA\SCEN-1.BLD
 Decompressing: C:\HAZARDI\DATA\SCEN-1.BLD
     Verifying: C:\HAZARDI\DATA\SCEN-1.BLD
       Writing: C:\HAZARDI\DATA\SCEN-2.BLD
 Decompressing: C:\HAZARDI\DATA\SCEN-2.BLD
     Verifying: C:\HAZARDI\DATA\SCEN-2.BLD
       Writing: C:\HAZARDI\DATA\SCEN-2.DAT
 Decompressing: C:\HAZARDI\DATA\SCEN-2.DAT
     Ver┌───────────────── PRESS ANY KEY ─────────────────┐
       W│ Please place the Master Distribution Disk labeled │
 Decompr│ "System Disk 1" version: 1.1 in drive A:         │
     Ver│ Press the [Esc] key to abort, any other key to continue... │
       W└───────────────────────────────────────────────┘
 Decompressing: C:\HAZARDI\DATA\SCEN-3.DAT
     Verifying: C:\HAZARDI\DATA\SCEN-3.DAT
       Writing: C:\HAZARDI\DATA\SWU8CTB.PIC
 Decompressing: C:\HAZARDI\DATA\SWU8CTB.PIC
     Verifying: C:\HAZARDI\DATA\SWU8CTB.PIC
```

As the files are copied from the installation diskettes to your hard disk, you will be able to see the progress of the installation on the screen and will be prompted to insert each of the distribution disks.

```
┌─────────────────────────────────────────────────────────────────────┐
│ The node "C:\HAZARDI" has been added to the existing PATH command     │
│                                                                       │
│                                                                       │
│                                                                       │
│                                                                       │
│                                                                       │
│              ══════════ PRESS ANY KEY ══════════                      │
│         ┌─────────────────────────────────────────────────┐          │
│         │ The AUTOEXEC.BAT file on drive C: has been created/modified. │
│         │ The original AUTOEXEC.BAT file has been renamed to AUTOEXEC.BAK │
│         │ If you have any problems with the new AUTOEXEC.BAT file when  │
│         │ you reboot your computer, you should restore the original file. │
│         └─────────────────────────────────────────────────┘          │
│                                                                       │
└─────────────────────────────────────────────────────────────────────┘
```

In order to locate the programs and data for HAZARD I, the installation module may need to create or modify the PATH statement in the automatic DOS startup file AUTOEXEC.BAT to direct DOS to the program directory for HAZARD I. If you wish to modify the file yourself, you may skip this step. However, the line must be added before the software will operate. Note that if you already have a complicated AUTOEXEC.BAT file, you may have to modify your DOS environment space manually. To modify the setup manually, see the next section on manual installation.

Once the installation is complete, you must reboot the computer before using HAZARD I to set the configuration modified in the last step of the installation. If your computer is equipped with RAM disks or other volatile storage media, you may wish to save its contents first before rebooting. If you do not automatically reboot the computer, you must change back to the hard disk once the installation is finished.

2.2.1 Customizing the Installation

While the complete automatic installation should be appropriate for most installations, there may be some custom hardware configurations where the installation is best completed by hand. As noted above, the programs which make up HAZARD I are provided on the diskettes in compressed form (to save disk space), so you must use the automatic installation program to copy HAZARD I to your hard disk. This section provides the details of the operations performed by the automatic installation module and outlines the steps necessary for a custom installation.

HAZARD I is installed in two subdirectories on your hard disk. One subdirectory is used to store the programs and database portions of HAZARD I and the other is used for the various data files that are supplied with the software and that are created through the use of the software. Typically, the two subdirectories will be

Program:	`C:\HAZARDI`
Data:	`C:\HAZARDI\DATA`

Once the two subdirectories have been created, the obvious step in the installation process is to copy all of the files on the supplied diskettes into the correct subdirectories of the hard disk. The files of HAZARD I are supplied on three 3½ in. or six 5¼ in. diskettes. The files from these diskettes are placed in the two subdirectories as follows:

Table 1. Program and data files in the HAZARD I software

Program Subdirectory	Data Subdirectory
CF_RPT.EXE	DATA.DAT
CONEFRM1.FMT	DEFAULTS.FCG
CONEFRM2.FMT	DEVFONT.004
CONFORM.FMT	DEVFONT.007
DECOMCC.DBF	DEVFONT.024
DECOMFC.DBF	DEVFONT.025
DETACT.EXE	EXITT.FCG
EXITT.EXE	F77L.EER
FAST.EXE	FASTPLOT.FCG
FAST.183	HLPTXT.V18
FASTPLOT.EXE	PARAM.FCG
FAST_IN.EXE	SCEN-1.BLD
FIREDATA.EXE	SCEN-1.DAT
FURNFORM.FMT	SCEN-2.BLD
FURNFRM1.FMT	SCEN-2.DAT
FURNFRM2.FMT	SCEN-3.BLD
HAZARD.EXE	SCEN-3.DAT
HAZARD.HLP	SCEN-4.BLD
FSETUP.EXE	SCEN-4.DAT
MATDIR.DBF	SCEN-5.BLD
MLTFUEL.EXE	SCEN-5.DAT
PHYFORM.FMT	SCEN-6.BLD
PHYFRM1.FTM	SCEN-6.DAT
PHYSICAL.DBF	SCEN-7.BLD
TENAB.EXE	SCEN-7.DAT
TOXFORM.FMT	SCEN-8.BLD
TOXFRM1.FMT	SCEN-8.DAT
TOXFRM2.FMT	THERMAL.TPF
TOXICITY.DBF	

Once all of the files have been copied to the hard disk, three additional steps are necessary to prepare HAZARD I for use on your machine.

First, two files in the root directory of the disk that contains DOS are created or modified. These two files, `AUTOEXEC.BAT` and `CONFIG.SYS` tailor the DOS operating system to be able to run HAZARD I. The file `CONFIG.SYS` must contain the two lines

```
FILES=15
BUFFERS=20
```

to tell DOS to reserve enough memory to allow simultaneous access to multiple files. Numbers larger than 15 for the FILES command or 20 for the BUFFERS command are acceptable.

The file `AUTOEXEC.BAT` must contain a line to allow HAZARD I to automatically locate its program and data files. The DOS PATH command is used to provide a set of subdirectories which are search automatically to locate executable program files. The PATH statement, located in the file `AUTOEXEC.BAT` must include the full path specification to your HAZARD I program directory. For the default program subdirectory described above, this command would be

```
PATH C:\HAZARDI
```

If you already have a complicated `AUTOEXEC.BAT` file, you may need to increase the size of the DOS environment space. By default, DOS reserves 160 bytes of space to store various system information such as the PATH command and SET commands. If you get the message "OUT OF ENVIRONMENT SPACE" when the machine boots, you must increase this space. For DOS version 3.0 or higher, this can be accomplished by placing the command

```
SHELL=C:\COMMAND.COM /P /E:nnn
```

in your `CONFIG.SYS` file (where nnn is the desired size of the environment space (in bytes for DOS 3.1 and above and in 16 byte paragraphs for DOS 3.0) and the DOS command processor is assumed to be in the root directory of drive C:). While values as large as 32,768 may be entered, a value of 512 bytes is

usually sufficient for HAZARD I. Refer to your DOS manual for details of the SHELL command.

Second, a file named `HAZARD.FCG` must be created in the HAZARD I program subdirectory to tell HAZARD I where to locate the data subdirectory. The first line in the file contains the full specification of the subdirectory. For the default data subdirectory described above, this file would be

        C:\HAZARDI\DATA

The second line in this file is normally just a blank line. It is used to pass any special options to the program modules of HAZARD I. This information is used by the programs for debugging purposes or for special hardware. Without a compelling reason to do so, leave this line blank (but it must be in the file as a blank line).

2.3 Running HAZARD I

```
  File   Create Input Data   Run Fire Model   Analyze Results        Help
 ┌─────────────────────┐
 │ Edit File (f6)      │
 │ View File (f7)      │
 │ Print File (f8)     │
 │ Copy File           │
 ├─────────────────────┤
 │ Shell to DOS (f5)   │
 │ Exit (f10)          │
 ├─────────────────────┤
 │ Setup               │          HAZARD I Version 1.1
 └─────────────────────┘
                    Building and Fire Research Laboratory
                 National Institute of Standards and Technology
                        Not Subject to Copyright
```
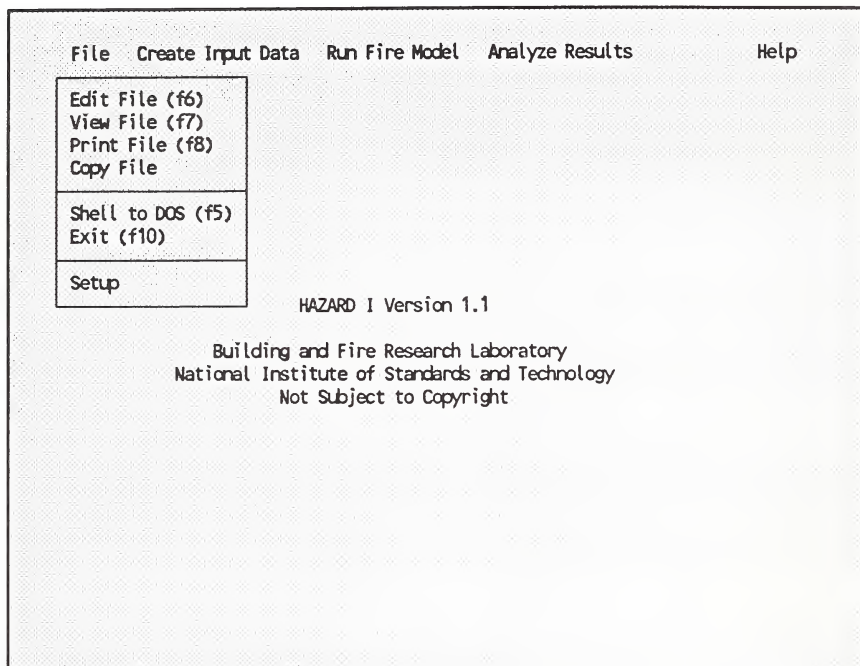
To begin HAZARD I simply type HAZARD and press an **enter**. This presents the HAZARD I shell which provides an interactive, user friendly, interface to HAZARD I. You may wish to skim section 4.1 of this Software User's Guide to become familiar with the concept of dialog boxes, the standard user interface used throughout HAZARD I. This will allow you to more manipulate the screens and understand the operation of HAZARD I.

The highlighted line at the top of the screen shows the major functions of HAZARD I. The first pulldown menu, **File**, is displayed. This menu allows you to view, edit, or print a file without leaving HAZARD I, exit temporarily to DOS to perform some DOS function unavailable from the shell, quit the

program, or change the program setup. To move the pulldown menu to the next set of menu, simply press the right arrow key.

```
┌─────────────────────────────────────────────────────────────────────┐
│                                                                     │
│  File   Create Input Data   Run Fire Model   Analyze Results    Help│
│       ┌──────────────────────────────────┐                          │
│       │ Interactive Data Input (FAST_in) │                          │
│       │ Multiple Fuel Packages (MLTFUEL) │                          │
│       │ Examine Database (FIREDATA)      │                          │
│       │ Detector Activation (DETACT)     │                          │
│       └──────────────────────────────────┘                          │
│                                                                     │
│                                                                     │
│                     HAZARD I Version 1.1                            │
│                                                                     │
│              Building and Fire Research Laboratory                  │
│            National Institute of Standards and Technology           │
│                     Not Subject to Copyright                        │
│                                                                     │
│                                                                     │
│                                                                     │
│                                                                     │
│                                                                     │
└─────────────────────────────────────────────────────────────────────┘
```
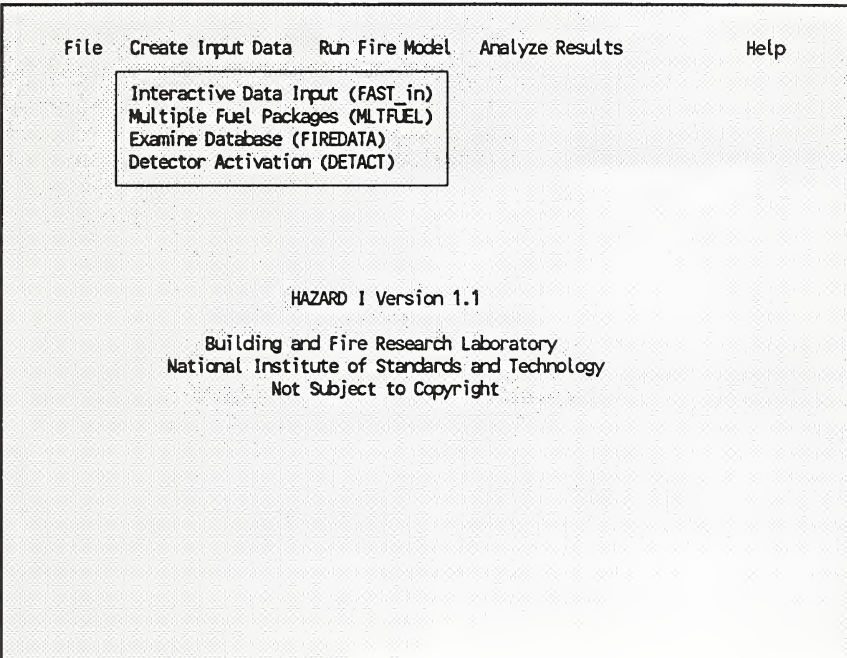
In this second pulldown menu, **Create Input Data**, the modules which are used to create input data for the models of HAZARD I are shown. The arrow keys or the mouse may be used to select the individual module to be executed. Press the down arrow key and the up arrow key several times and note that the highlighted selection bar moves to allow you to select any of the HAZARD I modules. To move the pulldown menu to the next set of modules, simply press the right arrow key.
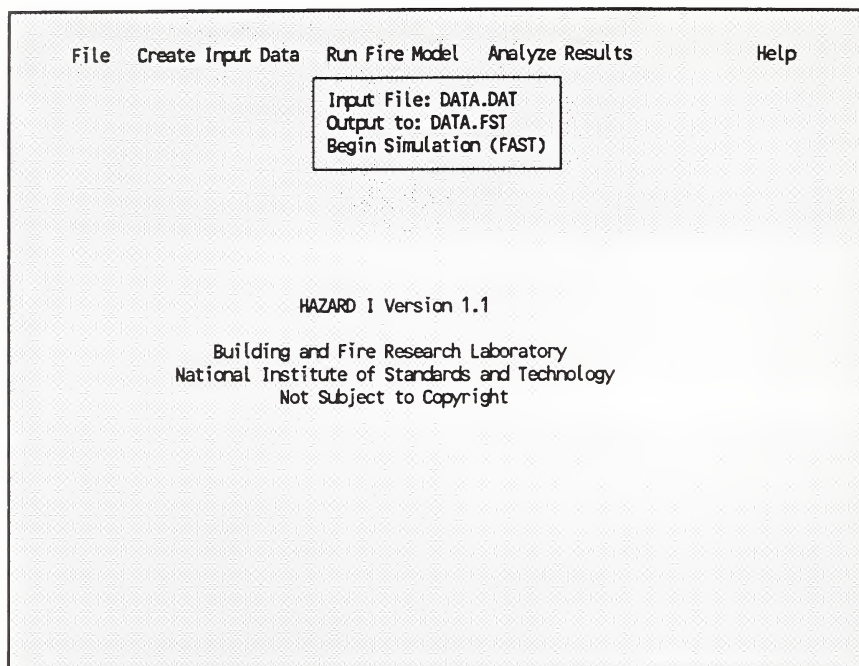
```
    File   Create Input Data   Run Fire Model   Analyze Results        Help
                              ┌─────────────────────────┐
                              │ Input File: DATA.DAT     │
                              │ Output to: DATA.FST       │
                              │ Begin Simulation (FAST)   │
                              └─────────────────────────┘




                            HAZARD I Version 1.1

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```

The third pulldown menu, **Run Fire Model,** is used to execute the FAST model. The three selections on this pulldown menu allow you to select an input file to be run by FAST, specify the destination for any printed output from the FAST model, and begin model execution. With the highlighted selection bar on the **Input File** selection, press **enter** to select an input data set to model.

```
  File    Create Input Data   Run Fire Model   Analyze Results        Help

┌────────────────────────── Select a File ──────────────────────────┐
│                                                                    │
│   File Spec  │*.DAT                                      │         │
│                                                                    │
│    ┌────────────────────────────────────────────────────────┐     │
│    │ ASTMF02.DAT   DEMO-F3.DAT   NIKEA.DAT    SCEN-2M.DAT     │     │
│    │ BASE.DAT      DEMO-F4.DAT   NOTEXT.DAT   SCEN-3.DAT      │     │
│    │ CVENT.DAT     DEMOF1.DAT    RANCH.DAT    SCEN-4.DAT      │     │
│    │ DATA.DAT      FLASH.DAT     RANCH1.DAT   SCEN-5.DAT      │     │
│    │ DEMO-F1.DAT   IGNITE.DAT    SCEN-1.DAT   SCEN-6.DAT      │     │
│    │ DEMO-F2.DAT   MDOT.DAT      SCEN-2.DAT   SCEN-7.DAT      │     │
│    │ ▉░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░░┘  │     │
│    └─────────────────────────────────────────────────────┘        │
│                                                                    │
│       < OK >              < Cancel >           < Help >            │
└────────────────────────────────────────────────────────────────────┘
```

With **Input File** selected, a list of the files with the default FAST input file extension of .DAT is presented. You may type in the name of any existing DOS file to select that file as the input file. To select one of the files in the list, press the tab key and use the arrow keys to select the file and press **enter**. For now, press the tab key, move the highlighted selection bar to the file DATA.DAT and press **enter**. Once selected, the screen returns to the previous menu selection. Note that the output file is changed to DATA.FST to correspond to the selected data file.

```
     File   Create Input Data   Run Fire Model   Analyze Results         Help

   ┌──────────────────────── Select a File ────────────────────┐
   │                                                            │
   │  File Spec │*.FST                              │           │
   │            └──────────────────────────────────┘           │
   │   ┌─────────────────────────────────────────────────┐     │
   │   │ Screen                                           │     │
   │   │ PRN                                              │     │
   │   │ LPT1                                             │     │
   │   │ LPT2                                             │     │
   │   │ LPT3                                             │     │
   │   │ NUL                                              │     │
   │   │ █▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒─┘ │     │
   │   └─────────────────────────────────────────────────┘     │
   │                                                            │
   │      < OK >              < Cancel >          < Help >      │
   └────────────────────────────────────────────────────────────┘
```
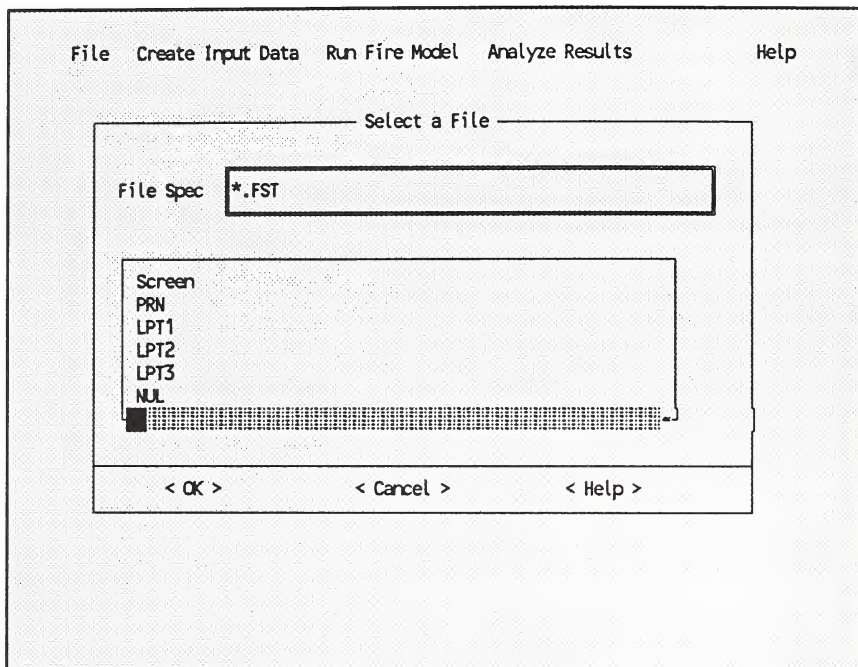
Now press the down arrow key to move the highlighted selection bar to the
Output to menu selection. Pressing the **enter** key brings up a list of the
possible devices where the printed output from FAST may be sent. Note that
by selecting DATA.DAT as the input file automatically sets the default **Output
to** designation to DATA.FST. Any valid DOS filename may be entered or the
devices on the list may be selected by pressing the tab key and using the arrow
keys. Move the highlighted selection bar to **Screen** to direct the output from
FAST to the screen and press **enter**.
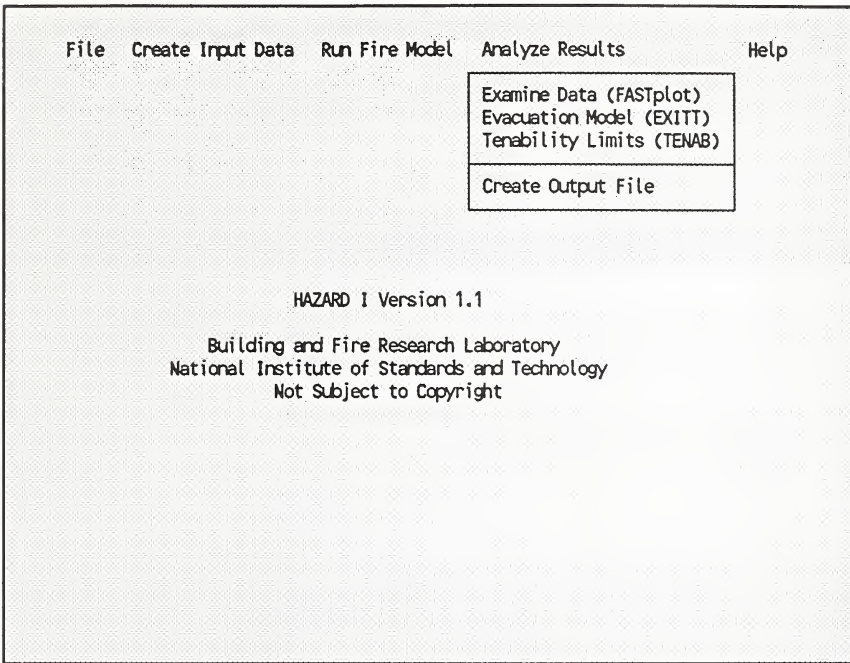
```
 File   Create Input Data   Run Fire Model   Analyze Results        Help

                                        ┌─────────────────────────────┐
                                        │ Examine Data (FASTplot)     │
                                        │ Evacuation Model (EXITT)    │
                                        │ Tenability Limits (TENAB)   │
                                        ├─────────────────────────────┤
                                        │ Create Output File          │
                                        └─────────────────────────────┘


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```

To analyze the results of a model run, press the right arrow key to present the
Analyze Results pulldown menu. This menu allows you to access the egress
and tenability modules, or to display the results graphically. In addition, you
can "recreate" a text output of a model from a specially formatted disk file
created by the model. Press the right arrow key to move to the **Help** menu.

```
    File   Create Input Data   Run Fire Model   Analyze Results           Help


                              ─── Help on Help ───
       ┌──────────────────────────────────────────────────────────────┐
       │ Help is available by pressing the Help key (f1) or by selecting  ≡ │
       │ the Help pulldown menu with the mouse or by pressing Alt-H.       █ │
       │ When the help screen is visible, you may view the selected help   ▒ │
       │ text by scrolling up and down the help text with the arrow keys   ▒ │
       │ or the mouse.  In addition, you may view this help message by     ▒ │
       │ selecting Help on Help, view any of the available help messages   ▒ │
       │ by selecting Keyword Help, or return to the program by            ▒ │
       │ selecting OK.  You can move between objects on the help screen    ▒ │
       │ with the Tab or the Shift-Tab key.                                ▒ │
       │                                                                   ▼ │
       └──────────────────────────────────────────────────────────────┘

         < OK >              < Help on Help >     < Keyword Help >
```

To access help which describes the function of each of the HAZARD I modules, press **enter**. A help screen is displayed describing the online help system. Press **esc** to remove the help text and continue.

```
┌──────────────────────────────────────────────────────────────────┐
│                                                                    │
│   FAST V 18.5     Initialization                        04/03/91   │
│                                                                    │
│                   FILE: DATA.DAT                                   │
│                                                                    │
│                                                                    │
│                                                                    │
│                                                                    │
│                                                                    │
│                                                                    │
│                                                                    │
│                                                                    │
│                                                                    │
│                                                                    │
│                                                                    │
│                                                                    │
│                                                                    │
│   ¦file¦    ¦help¦   ¦ 1R ¦ 3R ¦   ¦   ¦keys¦quit¦  input=>        │
│                                                                    │
└──────────────────────────────────────────────────────────────────┘
```

FAST_in is the first module in HAZARD I and is used to create input for the fire model FAST. From within the HAZARD Interface Shell, select the **Interactive Data Input (FAST_in)** from the **Create Input Data** pulldown menu by pressing **enter**. The first screen in FAST_in is **Initialization**, from which the starting file is selected. The default file shown is the last file that was worked on. To select this file, you would simply press **enter**. To select a different file, you may enter its name at the input prompt *or* press **f1** to obtain a list of the available files. You can also begin a file with a generic data set for a one-room or three-room building by pressing **f5** or **f6.**

```
FAST V 18.5      Initialization                                    04/03/91

  ASTMF02.DAT
  BASE.DAT          FILE: DATA.DAT
  CVENT.DAT
  DATA.DAT
  DEMO-F1.DAT
  DEMO-F2.DAT
  DEMO-F3.DAT       There are   28 files in this directory
  DEMO-F4.DAT
  DEMOF1.DAT
  FLASH.DAT
  IGNITE.DAT
  MDOT.DAT
  NIKEA.DAT
  NOTEXT.DAT
  RANCH.DAT
  RANCH1.DAT
  SCEN-1.DAT
  SCEN-2.DAT
  SCEN-2M.DAT
  SCEN-3.DAT
Data path not defined - using local directory

  <esc> to exit,  <enter> to select a file
```

Now, press **f1** to see the list of available files, which appears in a window at the left of the screen. Note that the list of files which appears are those actually on your machine, so the list may not match your list exactly. Also note that you are told the name of the directory being used (set in INSTALL) and how many files are in the directory.

Move the highlight bar to **DATA.DAT** and press **enter** to select this file.

NOTE: If you select a file which is not a valid FAST input file, a message will appear on the screen to inform you of that and you can make another selection.

```
FAST V 18.5   Overview                                         04/03/91

File: DATA.DAT      Title:      demo #1 a single compartment

Geometry                 Time            Ambient Conditions      (external)

Compartments     1   Simulation    180    Temperature    26.9        26.9
    Vents...     1       Print       0     Pressure 1.0E+05     1.0E+05
MV connects      0        Dump        5   Station elv.     0.0         0.0
                     Display      5    Wind speed                    0.0
                     Restart      0    Ref. height                  10.0
                                        Power law                  0.1600
Fire Specification

                 Type Specified fire(constrained)
    Species tracked    02  CO2    CO TUHC  H2O   CD   CT




Range: Alphanumeric ( 50)    Units: Name or Title
! go !    !help!   !    !    !    !unit!keys!quit!  input=> single compartment
```

This is the **Overview** screen, which presents a summary of the file. The text colors (typically bright white on color monitors unless customized during the installation) show that the only data which can be changed on this screen are the title and time steps. Move the highlight bar and note how the message line indicates the range of values and units for each data input.

Now try changing the **Print** interval by moving the highlight bar to it, entering a value, and pressing **enter**. If you enter a value outside the allowed range the value is not accepted and the message **Out of Range** appears on the message line.

Set the **Print** interval to 1 s, and move to the next screen with the **Page Down** key.

```
FAST V 18.5   Ambient conditions                                    04/03/91

                  (internal)  (external)

    Temperature     26.9        26.9
       Pressure   1.0E+05      1.0E+05
    Station elv.    0.0          0.0

      Wind speed                 0.0
      Ref. height               10.0
       Power law              0.1600

    Compartments     1    Maximum pressure differential      0.0
         Vents...    0       Maximum elevation change        2.30
      MV connects    0          Total internal volume        32.6








    Range:    -73.1 to    76.9   Units: Temperature in CELSIUS
    | go |     |help|    |    |    |    |unit|keys|quit|  input=>
```

You are now at the **Ambient Conditions** screen where the pre-fire interior and exterior conditions are specified.

The interior and exterior are individually specified so that seasonal variations can be simulated. Press f3 to see the help text for this screen, which explains the data which can be entered here. Press **ESC** to clear the help window.

Again, move the highlight bar over the data elements and note the ranges and units for each. However since these are fairly typical ambient values, we will not change them.

Proceed to the next screen by pressing **Page Down**.

```
FAST V 18.5   Geometry                                              04/03/91

        Dimensions

Compartment Number:        1
            Width:       3.30
            Depth:       4.30
           Height:       2.30
   Floor elevation:       0.0








Range:       0.0 to    150.0   Units: Distance in METER
| go |     |help|ADD |DEL |    |    |unit|keys|quit|   input=>
```

We have now reached the **Geometry** screen where the room dimensions are specified. You may add or delete compartments. The vents are displayed on this page, but must be changed on the **Vents** page.

Press **Page Down** to move to the **Vents** page.

HAZARD I, Version 1.1

```
FAST V 18.5   Vents(doors...)                                          04/03/91

          Dimensions

Compartment Number:       1
            Width:      3.30
            Depth:      4.30
           Height:      2.30
  Floor elevation:       0.0

      Vents(doors...)

      with respect to first room      wrt second room    - absolute -
    #  width   sill  soffit  wind    #   sill  soffit   a_sil  a_sof  Vent(1->4)
    1   1.07    0.0    2.0    0.0     2    0.0    2.0     0.0    2.0       1




Range:      0.0 to    4.30   Units: Distance in METER
| go |       |help|ADD |DEL |O/C |    |unit|keys|quit|  input=>
```

Move the highlight bar to the **Soffit** entry on the **Vent** page. Although the range message states that the soffit height is limited to 150 m, any height greater than the ceiling height (2.3 m) will be limited to the ceiling height. Try entering a value greater than 2.3 and note that the entry is changed to 2.3 automatically by the program. In general, a vent cannot be taller than the ceiling, lower than the floor, or wider than the longest dimension of the first room that it connects.

Move to the next screen by pressing **Page Down**.

```
FAST V 18.5   Fans, Ducts,...                              04/03/91

          Dimensions

Compartment Number:        1
            Width:      3.30
            Depth:      4.30
           Height:      2.30
   Floor elevation:      0.0

     Exterior Connections

Compartment      # node      Orientation      Height         Area




No connections to display
                           Units:  H or V
 | go |      |help|ADD |DEL |DUCT|FAN |unit|keys|quit|   input=>
```

The **Fans and Ducts** screen is where all mechanical ventilation fans, ductwork, and connections to rooms is made. Since this example is a simple one room simulation with no mechanical ventilation, no fans or ducts are displayed in the lower half of the screen. The **ADD** key (f4) and **DEL** key, (f5) allow the addition and removal of connections between rooms and mechanical ventilation systems. The **FAN** key (f6) and **DUCT** key (f7) bring up additional screens to specify the details of the system.

For now, just move to the next screen by pressing **Page Down**.

```
FAST V 18.5    Thermal properties                                  04/03/91

Compartment Number        1

Ceiling properties:      OFF
  Floor properties:      OFF
   Wall properties:      OFF




Range: Alphanumeric ( 8)     Units: Name or Title
¦ go ¦     ¦help¦ADD ¦DEL ¦DATA¦    ¦    ¦keys¦quit¦  input=>
```

The **Thermal Properties** screen is where the wall, ceiling, and floor materials for each room are specified. This is done using the *name* of a material or assembly from the **Thermal Database**.

You can press the **DATA** key (**f6**) to access the database and find an appropriate material, then **Esc** to return to the properties screen and type the material name at the input prompt. Or, you can treat the surface as *adiabatic* by turning it off with the **DEL** key (**f5**). If you want to set a number of entries to the same material, you can use the **PICK** feature. Go to the database screen (**f6**) and highlight any value for the material you wish to use. Press the **PICK** key (**f6**) and the program will return to the properties screen, and replace the highlighted entry with the picked material. Now **Page Down** to the next screen.
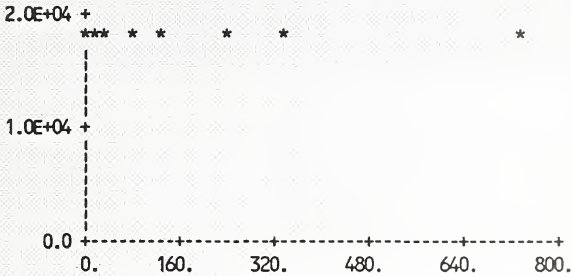
```
FAST V 18.5    Fire Specification                                04/03/91

      Heat of C   Lim O2    Rel Hum.   GMW        Pos     Room     Type
        1.8E+04    3.00        0.0     16.0         1       1        2


                  2.0E+04 +
   ┌──────────┐           ***  *  *       *     *                    *
   │ 1  1.8E+04│          |
   │ 2  1.8E+04│          |
   │ 3  1.8E+04│          |
   │ 4  1.8E+04│          |
   │ 5  1.8E+04│  1.0E+04 +
   │ 6  1.8E+04│          |
   │ 7  1.8E+04│          |
   │ 8  1.8E+04│          |
   └──────────┘          |
                   0.0 +--------+---------+---------+---------+---------+
                       0.     160.     320.      480.     640.      800.


     Pyrolysis Heat_release  Height  Area  H/C  CO/CO2  C/CO2  HCN  HCL  Ct

  Range:   0.0010 to  6.0E+04    Units: Heat of Combustion in KILOJOULE/KILOGRAM
  | go |      |help|ADD |DEL |MOD |      |unit|keys|quit|  input=>
```

The **Fire Specification** screen requires the most data entry. For time dependent variables, data are entered in a table and displayed in a graph, both in the center of the screen. Note that the text screen graph is not as precise as the actual numbers entered and should only be used as a visual indication of the curve.

Move the highlight bar across the entries to see which inputs are time dependent. Note that some of the data elements are in the *protected text* color. This indicates that these are off. To activate them, highlight the element and press the **ADD** key (**f4**). This will bring up a blank table and graph. Remember that chemistry is only done in a constrained (**Type 2**) fire. Thus, if you change the **Type** to 1, all species inputs (except CT) will be turned off. Also, the **Heat of C**, **Pyrolysis**, and **Heat_release** inputs are related. If you enter all three, the last two entered may force the third to change to be consistent. Now, press **Page Down** to go to the next screen.

HAZARD I, Version 1.1

quick estimates   <f5> asks for a time interval

run time graphics   <f6> use existing display file (if it exists)

save data file(s)   <f7>

write to log file   <f8> no

| go | |help| | | | | | |quit|

The **Files** screen takes no input, but rather performs its actions with function keys. When you are ready to save your file, you press **f7** at the **Files** screen, which brings up the files screen. Note that since we changed the **Print** interval, the file is marked as "modified and not saved." This is also where we name the dump file or change the thermal database file used for this run.

If there is a file on the disk with the same name, you will be asked if you wish to overwrite it. A "no" will bring you back to the input prompt to select a different file name.

```
FAST V 18.5   Overview                                    04/03/91

File: DATA.DAT      Title:       demo #1 a single compartment

Geo┌Overview         │    Time          Ambient Conditions    (external)
   │Ambient conditions│
Com│Geometry          │imulation   180    Temperature   26.9        26.9
   │Vents(doors...)   │   Print      0      Pressure 1.0E+05     1.0E+05
MV │Fans, Ducts,...   │   Dump       5    Station elv.   0.0         0.0
   │Thermal properties│   Display    5    Wind speed                 0.0
   │Fire Specification│   Restart    0    Ref. height               10.0
   │Files,...         │                   Power law              0.1600
Fir│Version and Setting│
   └──────────────────┘
   ─           Type Specified fire(constrained)
     Species tracked    O2  CO2   CO TUHC  H2O   CO    CT




Range: Alphanumeric ( 50)     Units: Name or Title
<enter>, <f1> for help, <esc> to exit
```

Now that we have seen the basic functions of, and data entry to each of the screens in FAST_in, we will examine some more advanced concepts.

While the **Page Up** and **Page Down** keys are convenient for moving one screen at a time, you sometimes want to jump screens. Pressing **f1** (labeled **go**) brings up a **navigation window**. Simply move the highlight bar to the screen you want and press **enter**.

Now use this feature to jump to the **Geometry** screen.

```
FAST V 18.5   Geometry                                              04/03/91

          Dimensions

Compartment Number:        1
             Width:     3.30

     Floor  ┌─────────────────────────────────────────────────┐
            │ Compartment #                              2      │
            │                                                   │
            │ Width                                             │
            │                                                   │
            │ Depth (breadth)                                   │
            │                                                   │
            │ Interior height                                   │
            │                                                   │
            │ Height of floor above reference level            │
            │ (reference is specified in "Ambient")            │
            └─────────────────────────────────────────────────┘



Range:      0.0 to    150.0   Units: Distance in METER
<esc> to exit, <f2> accept data                      input=>
```

To **delete a compartment,** highlight any dimension of that compartment and press **f5 (DEL).** *NOTE: You cannot delete the compartment that contains the fire.*

To **add a compartment,** press **f4 (ADD)** while on the rooms page. This opens a window asking for the data . After entering the data, press **f1** to add the data to your file or **esc** to return to the screen and *not* add the data to the file. *NOTE: The range and units shown are for the input that you are on within the* ***add a compartment*** *window. If you want to change units, you must do so before you go into the add mode.* The new room and the outdoors are *automatically* numbered so that the outdoors is always the highest numbered compartment.
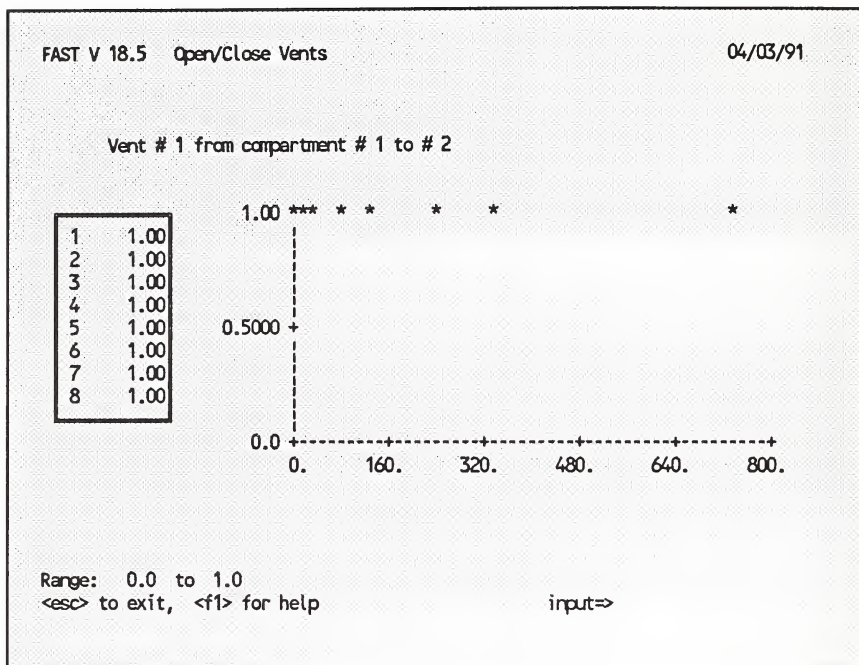
Once you accept the data, it will be displayed on the **Geometry** screen. Now press **esc** to return to the **Geometry** screen and **Page Down** to move to the **Vents** page.

```
FAST V 18.5    Vents(doors...)                          04/03/91

            Dimensions

Compartment Number:        1
            Width:      3.30

    Floor │First Compartment
          │
        V │Second Compartment
          │
     with │Vent number                      solute -
    #  widt│                               l  a_sof Vent(1->4)
    1  1.0│Width                               2.0    1
          │
          │Soffit (with respect to first comp)
          │
          │Sill (with respect to first comp)


Range:       1 to     2  Units: Compartment number
<esc> to exit, <f2> accept data                input=>
```

Adding or deleting a vent is identical to adding or deleting a room except it is done from the Vents(doors...) screen. Press **ADD (f4)** to see the **add a vent** window. *NOTE: The order of the compartments (first or second) entered makes no difference other than that the soffit and sill dimensions are with respect to the floor of the first compartment.*

Now press **esc** to return to the screen.

```
FAST V 18.5    Open/Close Vents                                    04/03/91


        Vent # 1 from compartment # 1 to # 2

                          1.00 ***  *  *      *     *                    *
        ┌──────────┐           ¦
        │ 1    1.00│           ¦
        │ 2    1.00│           ¦
        │ 3    1.00│           ¦
        │ 4    1.00│           ¦
        │ 5    1.00│  0.5000 + ¦
        │ 6    1.00│           ¦
        │ 7    1.00│           ¦
        │ 8    1.00│           ¦
        └──────────┘           ¦
                          0.0 +---------+---------+---------+---------+---------+
                              0.     160.     320.     480.     640.     800.




    Range:   0.0  to  1.0
    <esc> to exit,  <f1> for help                        input=>
```

The final operation done on this screen is to **modify a vent**, which means to open or close the vent at a previously defined time interval.

Move the highlight bar to the desired vent and press **O/C (f6)** to bring up the **Open/Close Vents** screen. This presents a table and graph similar to those used for time dependent variables on the **Fire Specification** screen. The default values are all 1.0, indicating 100% open. At any existing interval, the vent can be closed by entering a 0 or open any fraction by entering the appropriate value between 0 and 1. *NOTE: The value entered multiplies the width of the associated vent.* As with other time dependent variables, a linear interpolation is performed between intervals.

Press **esc** then use the **navigation window** to move to the **Fire Specification** screen.

```
FAST V 18.5   Modify Time Interval                                    04/03/91



               The time line shows the relative size of the time intervals
        ┌──────────┐
        │ 1   20.0 │
        │ 2   20.0 │   *-*-*---*---*------*------*--------------------*
        │ 3   50.0 │
        │ 4   50.0 │
        │ 5  100.0 │
        │ 6  100.0 │
        │ 7  400.0 │   Press <f4> to split the interval
        └──────────┘
                      Press <f5> to delete the interval




    Range:    1.00 to  8.6E+04   Units: Time in SECOND
    <esc> to exit, <f1> for help, <f8> to change units    input=>

```

Time dependent variables can change value only at a specified time **interval.** Thus, we must be able to change these intervals. *NOTE: The set of time intervals form a single time line which applies to all time dependent variables.*

Navigate to the **Fire Specification** screen and highlight any time dependent variable except species. Press **MOD (f6)** to obtain the **Modify Time Interval** screen. Highlight an interval and press f4 to split it in half, f5 to delete it, or **input** a value from the keyboard. The time line display will show the changes as they are entered. Press **esc** to return to the **Fire Specification** screen.

```
┌─────────────────────────────────────────────────────────────┐
│                                                               │
│                                                               │
│                                                               │
│                                                               │
│                                                               │
│           ┌─────────────────────────────────────────┐        │
│           │One or more of the data files have been altered│   │
│           │and not saved.  Do you want to quit anyway?│        │
│           └─────────────────────────────────────────┘        │
│                                                               │
│                                                               │
│                                                               │
│                                                               │
│   Yes or No                            input=>                │
└─────────────────────────────────────────────────────────────┘
```
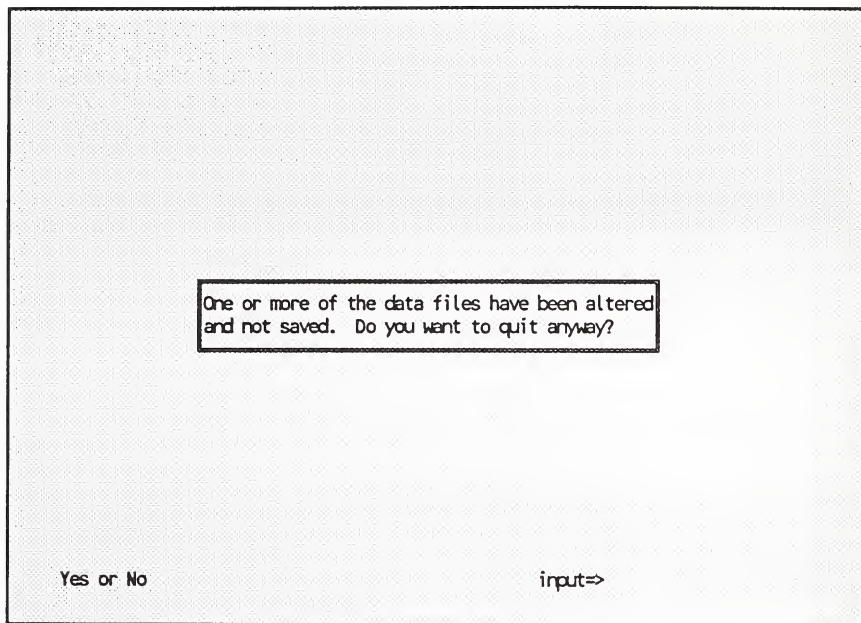
To end FAST_in, press **f10**. Since you have made changes to the input file, you will be told that the modified file has not been saved. If you answer **N**, you will return to FAST_in and can save the file. For now answer **Y** to leave FAST_in without changing the data file.

3 Learning

In section 2, we examined the use of the Hazard I shell, Fast_in, and FAST to simulate a building fire. In this chapter, we will learn how to use the remaining modules of HAZARD I to perform a hazard analysis. This will be accomplished by working our way through one of the example cases documented in the **Reference Guide.**

The modules MLTFUEL, FIREDATA, DETACT, EXITT, and TENAB operate in a traditional, interactive manner. That is, they obtain input by asking a series of questions which are answered in a specific sequence. They are not as "user friendly" (e.g., they operate only in SI units), but their use is generally straightforward. In HAZARD II, we plan to implement a user interface to these modules similar to FAST_in, called FAST_out.

3.1 Organizing Data Files in HAZARD I

By using a consistent set of naming conventions for the files used and generated by HAZARD I and separating your data files by topics as appropriate, use of the large number of data files within HAZARD I becomes more manageable. This section details the naming conventions used by the software and introduces the concept of multiple data subdirectories to organize your work with HAZARD I.

3.1.1 Naming Files

HAZARD I allows the use of any valid MS-DOS filename (up to eight characters with an optional, three-letter extension) for user-named data files created by the modules. However to assist the user, we have designed the software to display, and sometimes default to, data files of the specific type required at that point. To differentiate among the different files used within

HAZARD I, we **assume** a specific and consistent file naming scheme. Thus to benefit from this feature, the user must follow this file naming convention.

As illustrated in the HAZARD I flowchart, all data files for a given case under study should use a common filename (up to eight characters) which is descriptive of that case. For example, a case involving a townhouse might use **TWNHOUSE,** or an analysis of a building for a client named Collins might be called **COLLINS.** The differentiation of the specific data file type comes from the (three letter) extension. The extensions <u>assumed</u> by the HAZARD I software are:

Extension	File Type
`.TPF`	Thermal Properties database file for FAST and FAST_in
`.DAT`	Input data file to FAST
`.FST`	Printer output from FAST
`.DMP`	Output data file from FAST to FASTplot and TENAB
`.BLD`	Building input file to EXITT
`.EXT`	Printer output from EXITT
`.EVA`	Evacuation map from EXITT to TENAB
`.TEN`	Printer output from TENAB
`.PLT`	Output data file from TENAB to FASTplot

One additional file is used by HAZARD I for storage of graphics output files from FASTplot. Since it may be desirable to create multiple graphs from a single test case, the file names for this type of file are different than those above. For graphics files, the form is

`HPGL.nnn` — Plotter file from FASTplot formatted for a Hewlett-Packard plotter. nnn is an automatically selected three digit number from 000 to 999.

3.1.2 Data Subdirectories

By using multiple data subdirectories, you can organize your work with HAZARD I by project or topic and maintain a manageable set of data files to be used at one time. Sets of data can be separated by topic such as furniture fires, kitchen fires, and the like; by project sponsor; or by any convenient categorization. Files for each of the separate categories may be kept in a separate subdirectory on your hard disk and the shell has the capability to switch to any other data subdirectory. To switch, you can use the **Setup** menu selection on the **File** menu in the shell as described in section 4.1.2 of this **Software User's Guide**.

3.2 The Example Case

The example case with which we will be working is based on scenario 2, the kitchen grease fire in the ranch house. As we proceed, you may wish to compare your results to that in the **Example Cases** volume for this case.

3.3 Defining the Context

The product of interest in this case is kitchen cabinets for which we wish to estimate the contribution to the occupant hazard for their most common involvement in residential fires. The product is sold for residential use for both new construction and for remodeling. Such cabinetry typically includes both base and overhead assemblies, and may include free standing units (islands). While consisting of a series of individual units, they are normally installed abutting each other such that long, continuous surfaces (for flame spread) are formed. We wish to compare our current product with one made with a new core material which burns at half the rate, but uses a nitrogen-containing filler resulting in a 1% yield of HCN.

A review of fire incident data (NFIRS) reveals that the primary ignition exposure comes from grease fires on the stove surface, and secondarily from

fires in counter top appliances (which will not be addressed directly in this example). The ranch house is selected as the target building since it represents approximately 70% of the U.S. single-family housing stock. A typical ranch house arrangement is provided in the HAZARD I example cases discussed in chapter 4 of the **Technical Reference Guide.** If the performance of the cabinets in other houses (two-story, apartment, or mobile home) or ignition scenarios were of interest, these could be analyzed in a similar manner.

3.4 Defining the Scenario(s) of Concern

Since occupant characteristics in homes are extremely variable, it is decided that a mixed family composition should be used to represent the range of characteristics which might be expected. The family members selected include:

> The father, aged 30, located in the master bathroom.
> The mother, aged 30, in the hall near the washer/dryer.
> A daughter, aged 7, in the living room watching TV.
> A son, aged 5, watching TV with his sister.
> A grandmother, aged 71, in bedroom 3.

All occupants are assumed to be awake and fully capable at the time of the fire. The doors to the grandmother's room (#3), the master bedroom, and the master bath are closed (all others are open). For this example, only a single scenario will be examined.

3.5 Calculating the Hazard

Following the Step-by-Step Procedure for Conducting a Hazard Analysis in chapter 3 of the **Technical Reference Guide,** the HAZARD I software is used to predict the consequences of the scenario described above with the current cabinets.

3.5.1 FIREDATA

The first step is to search FIREDATA for any appropriate data on the burning rates of a pan of oil and kitchen cabinets. From within the shell, select FIREDATA from the **Create Input Data** pulldown menu.

```
            CENTER for FIRE RESEARCH
        FIRE PROPERTIES INFORMATION SYSTEM


        To update and retrieve fire property data on
        materials tested by rate of heat release calorimeters;
        cone and furniture, and toxicity protocols; Cup
        Furnace and University of Pittsburgh.


              A)dd     E)dit    D)elete
                  F)ind     L)ist
                       Q)uit


        Enter Selection:
```

The initial screen of FIREDATA asks whether you wish to A)dd, E)dit, D)elete, F)ind, L)ist, or Q)uit. Searching is done with Find. The other functions are discussed in the FIREDATA section of chapter 4.

```
┌─────────────────────────────────────────────────────────┐
│                                                         │
│   ┌──────────────────────────────────────────────────┐  │
│   │  Data is retrieved by a two pass procedure        │  │
│   │ ┌──────────────────────────────────────────────┐ │  │
│   │ │ 1-Material keyword(s) is entered and a data   │ │  │
│   │ │ base selected. Material identification field  │ │  │
│   │ │ is searched for presence of keyword(s). The   │ │  │
│   │ │ Material Code & Identification fields are listed│ │  │
│   │ └──────────────────────────────────────────────┘ │  │
│   │ ┌──────────────────────────────────────────────┐ │  │
│   │ │ 2-Desired MATERIAL CODE is entered. Program   │ │  │
│   │ │ will display data until end-of-file or STOP   │ │  │
│   │ │ command is entered.                           │ │  │
│   │ └──────────────────────────────────────────────┘ │  │
│   └──────────────────────────────────────────────────┘  │
│                                                         │
│  Press any key to continue...                           │
│   Enter Material Name:                                  │
│                                                         │
└─────────────────────────────────────────────────────────┘
```

Selecting **F** brings up a screen with instructions and a request for a word on which to search. Since we are looking for burning rate data on oil, we will type **oil** at the prompt. This brings up a request for which database to search. Select f)urniture calorimeter for data on full-scale items.

```
┌─────────────────────────────────────────────────────────┐
│                                                         │
│  CKG001        COOKING OIL,CORN;COTTONSEED;ETC IN 12IN.PAN│
│  Press any key to continue...                           │
│   Enter MATERIAL CODE or 'EXIT' CKG001                  │
│                                                         │
└─────────────────────────────────────────────────────────┘
```

After searching the database, we obtain a single matching entry. Entering the material code (shown at the left) **CKG001** at the prompt brings up the first page of data.

```
                  Decomposition Data from Furniture Calorimeter

       Material Code: CKG001
       Material ID: COOKING OIL,CORN;COTTONSEED;ETC IN 12IN.PAN
       Configuration:POOL
       Ignition Source:


       Initial Mass:    0.000 kg   Final Mass:   0.000 kg
       Ignition Time:   0.0 s

                          Units     Average
       Heat of Combustion  kJ/kg    40000.0
       CO    Yield         kg/kg     0.0000
       CO2   Yield         kg/kg     0.0000
       HC    Yield         kg/kg     0.0000
       HCl   Yield         kg/kg     0.0000
       HCN   Yield         kg/kg     0.0000
       H2O   Yield         kg/kg     0.0000
       SOOT  Yield         kg/kg     0.0000
       Extinction Area     m2/kg     0.000
       Press any key to continue...
```

This page gives the general information on this data entry along with selected average data values such as the average (net) heat of combustion. If you do not intend to print this data sheet, copy down the information you need before moving to the second page of data.

For this screen you will need the heat of combustion value (40000 kJ/kg) for input to MLTFUEL.

	Heat	Mass	Time Dependent Data CO	CO2		
Time (s)	Release (kW)	Loss (kg/s)	Yield (kg/kg)	Yield (kg/kg)	Yield (kg/kg)	Yield (kg/kg)
0.0	0.00	0.000000	0.000	0.000	0.000	0.000
5.0	116.00	0.002920	0.000	0.000	0.000	0.000
1000.0	116.00	0.002920	0.000	0.000	0.000	0.000
0.0	0.00	0.000000	0.000	0.000	0.000	0.000
0.0	0.00	0.000000	0.000	0.000	0.000	0.000
0.0	0.00	0.000000	0.000	0.000	0.000	0.000
0.0	0.00	0.000000	0.000	0.000	0.000	0.000
0.0	0.00	0.000000	0.000	0.000	0.000	0.000
0.0	0.00	0.000000	0.000	0.000	0.000	0.000
0.0	0.00	0.000000	0.000	0.000	0.000	0.000

Enter P)rinter or E)xit:

The second page presents the time dependent data for this item. Note that the burning rate is constant (as expected for a flammable liquid of constant surface area). Also note that there are no data available for species production rates for this item (the database fills empty cells with zeros). Again, copy down the required data (mass loss rate for MLTFUEL) or select P)rinter to print the data sheet.

This will bring you back to the request for a search word. Entering cabinet (to look for a kitchen cabinet) brings only a television cabinet, which is not appropriate as a kitchen cabinet. In fact, we chose to use data for a wardrobe closet, which can be searched by either or both of these words. Doing so returns the material code CLT001, and the data sheet presented in the two screens on the next page. Such substitutions can be based on similarity in mass, surface area, material, etc.

A list of all of the data contained in the database can be obtained with the L)ist option detailed in chapter 4.

```
              Decomposition Data from Furniture Calorimeter

     Material Code: CLT001
     Material ID: WARDROBE CLOSET,PLYWOOD,FR PAINT  NBSIR83-2787 TEST42
     Configuration:CENTER
     Ignition Source: CARDBOARD BOX/PAPER 0.9KG


     Initial Mass:  37.330 kg  Final Mass:   0.000 kg
     Ignition Time:   0.0 s

                      Units      Average
     Heat of Combustion  kJ/kg    15900.0
     CO    Yield       kg/kg       0.0000
     CO2   Yield       kg/kg       0.0000
     HC    Yield       kg/kg       0.0000
     HCl   Yield       kg/kg       0.0000
     HCN   Yield       kg/kg       0.0000
     H2O   Yield       kg/kg       0.0000
     SOOT  Yield       kg/kg       0.0000
     Extinction Area   m2/kg       0.000
     Press any key to continue...
```

We note that the wardrobe exhibited a very high peak of energy released at 170 s due to the rapid burning of its contents. Since this would be unrepresentative of a kitchen cabinet, we choose to lower the mass loss rate at this one data point (0.333 kg/s) to the value at the prior interval (0.0817 kg/s), and flatten the peak of curve. As was done for the cooking oil, copy down or print the information from the two screens of information. For the wardrobe, you will need the heat of combustion, mass loss rate and yields for CO, CO_2, and soot.

When finished with the database, simply press enter until the screen for selecting the database to search comes up. Selecting E)xit here, and Q)uit on

	Heat	Mass	CO	CO2	SMOKE	
Time	Release	Loss	Yield	Yield	Yield	Yield
(s)	(kW)	(kg/s)	(kg/kg)	(kg/kg)	(kg/kg)	(kg/kg)
0.0	0.00	0.000000	0.000	0.000	0.000	0.000
30.0	0.00	0.000000	0.000	0.000	0.000	0.000
100.0	500.00	0.031400	0.075	0.320	0.016	0.000
130.0	1300.00	0.081700	0.082	0.610	0.019	0.000
170.0	5300.00	0.333000	0.010	1.130	0.004	0.000
220.0	250.00	0.015700	0.024	1.510	0.000	0.000
230.0	600.00	0.037700	0.029	0.930	0.000	0.000
370.0	250.00	0.015700	0.038	0.600	0.000	0.000
1200.0	50.00	0.003100	0.000	0.790	0.000	0.000
0.0	0.00	0.000000	0.000	0.000	0.000	0.000

Time Dependent Data

Enter P)rinter or E)xit:

the first FIREDATA screen will take you back to the shell.

3.5.2 MLTFUEL

When multiple items are involved in a fire, they usually become involved in a sequence. That is, one is ignited and after growing to a certain size, ignites the next. MLTFUEL is a utility module which converts the data on multiple items burning simultaneously into a single burning rate curve as required by FAST. While the units of the results will be the same as the units input (everything is multiplied by dimensionless parameters), it is suggested that SI units be used to avoid confusion later.

MLTFUEL allows you to input individual heat of combustion, mass loss rates, and species yields as presented in the description of FIREDATA, above. All of the species yields calculated by the FAST model can be determined for up to five items burning simultaneously.

3.5.2.1 Establishing the time-line

The rate of heat release curve for the first item ignited (the pan of oil) is considered first, in this case, a constant rate of 116 kW. For this example, we assume that the burning oil boils over at 120 s, igniting the cabinet. Thus, the ignition delay in the rate of heat release curve for the wardrobe cabinet is 120 s. For MLTFUEL, this 120 s delay is entered manually by adding 120 s to the time values obtained from FIREDATA for the wardrobe (the 100 s value becomes 220 s for instance).

3.5.2.2 Entering the data

MLTFUEL can now be selected from the shell. We have two items burning together. In MLTFUEL, items are added one by one until the desired composite burning curve is obtained. The initial screen for MLTFUEL allows you begin input for the first item.

MLTFUEL Version 2.0

Once information for the first item has been entered, you may add or delete an item by using the function keys. After the name of the item and the heat of combustion have been entered, you can select from eight different quantities for each item. A mass loss rate curve must be entered for each item. All species entries for an item are optional. Once the data has been entered, the heat of combustion, mass loss rate, and species yields may be viewed or printed with the function keys. Data for any quantity may be changed by selecting the item, quantity, and time with the arrow and enter keys and modifying the selected entry.

Description: Cooking Oil
Heat of Combustion: 40000

MLTFUEL Version 2.0, Created April 1, 1989

For item 1 (the oil), enter the name of the item and the heat of combustion you obtained from FIREDATA (Cooking Oil and 40000 kJ/kg). Press **enter** after each entry. Once you have entered the heat of combustion, you will be presented with a second screen showing a list of quantities which may be entered.
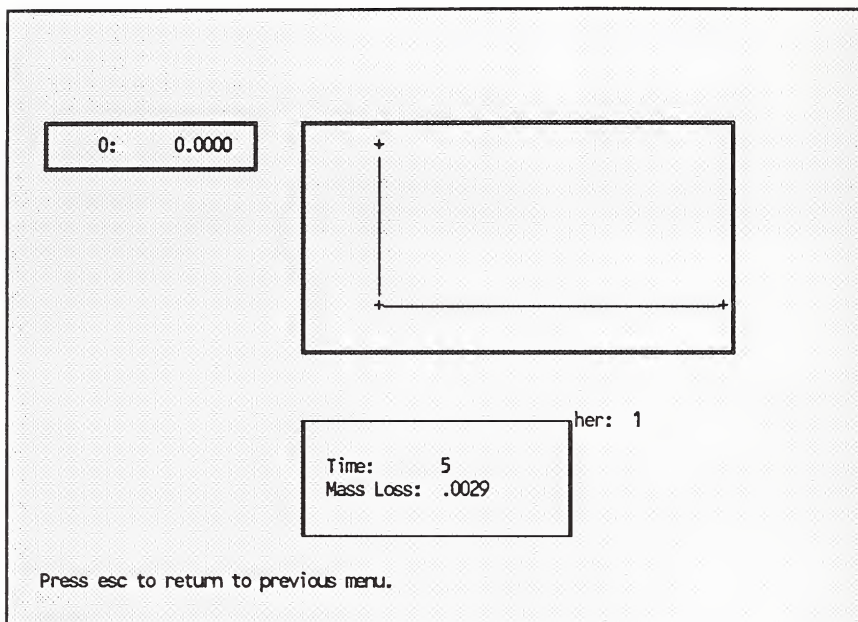
```
Mass Loss
Hydrogen
Carbon Monoxide
Carbon Dioxide
Soot
HCN
HCL
CT
```

```
Number of Items Burning Together:  1
Item: Cooking Oil
Quantities Included:
Number of Data Points:  1
```

Press esc to return to previous menu.

From this screen, you select the quantity to be entered. The mass loss rate and the species which can be used by the FAST model are available. A summary of the current item is shown in the lower right hand corner of the screen. Although we will eventually have two items burning together in this composite fire, only the first one has been added at this point. Thus, only one item is shown in the summary.

Using the arrow keys or the mouse, position the highlighted selection bar over **Mass Loss** and press enter. Initially, the only entry is a time of **0** and a rate of **0**. For the cooking oil, this is a correct entry so press **f4** to **ADD** another entry.

```
        0:      0.0000              +
                                    |
                                    |
                                    |
                                    +──────────────────────+
                                               her:  1
                        Time:         5
                        Mass Loss:   .0029


   Press esc to return to previous menu.
```

Enter **5** for the time and **.00292** for the mass loss rate. Press **esc** to return to the quantity selection menu. Since species yields for the cooking oil are all zero, we have completed entry for this item. If you discover a mistake in an entry, simply position the highlighted menu selection bar over the item and press **enter**. The current values for the item appear and may be changed. Try this with the 5 s entry and note that the entry box appears in the lower right hand corner of the screen with the values for this entry. Since the entry is correct, just press **enter** twice to return to the quantity selection menu. Finally, press **esc** again to return to the main program screen to enter the second item.

```
                        MLTFUEL Version 2.0
 ┌─────────────────────────────────────────────────────────┐
 │ Burning Item        Burn Time       Quantities Included  │
 │ Cooking Oil         0  to  5        MDOT                  │
 └─────────────────────────────────────────────────────────┘




 ┌───────────────────┐
 │ Cooking Oil       │
 └───────────────────┘
```

Since there are more intervals and more species to be entered for the kitchen cabinets, the entry will be more involved. Press the **ADD** key, **f4**, to add the second item and enter the name of the item (we used **Kitchen Cabinet**) and the heat of combustion (**15900** from the FIREDATA output). As before, pressing **enter** presents a list of species to be added to the calculation. With MLTFUEL, each curve is entered separately. Thus, the timeline and mass loss curve will be entered first and followed by the yield curves for each species.

Data for Kitchen Cabinets
(modified from FIREDATA wardrobe data)

Time	Mass Loss	CO	CO_2	Soot
150	0.	0.	0.	0.
220	0.0314	0.075	0.320	0.016
250	0.0817	0.0817	0.610	0.019
290	0.0817	0.0817	0.610	0.019
340	0.0157	0.024	1.510	0.
350	0.0377	0.029	0.930	0.
490	0.0157	0.038	0.600	0.
1320	0.0031	0.	0.790	0.

Since the ignition time for the kitchen cabinets is assumed to be 120 s, the times from the FIREDATA output was shifted by 120 s and the data entered as shown in the table above. Note also the mass loss and yields for the high peak at 290 s in the table above (170 s in the FIREDATA output) were replaced with the value at the prior time interval as discussed in the FIREDATA section, above.

```
  150:      0.0000        0.0817+  **
  220:      0.0314
  250:      0.0817
  290:      0.0817
  340:      0.0157                    *      *
  350:      0.0377
  490:      0.0157                       *    *
 1320:      0.0031           0   *_____*
                                 150                    1320
```

```
                                          her:  2
                    Time:       1320
                    Mass Loss:  .0031
```

Press esc to return to previous menu.
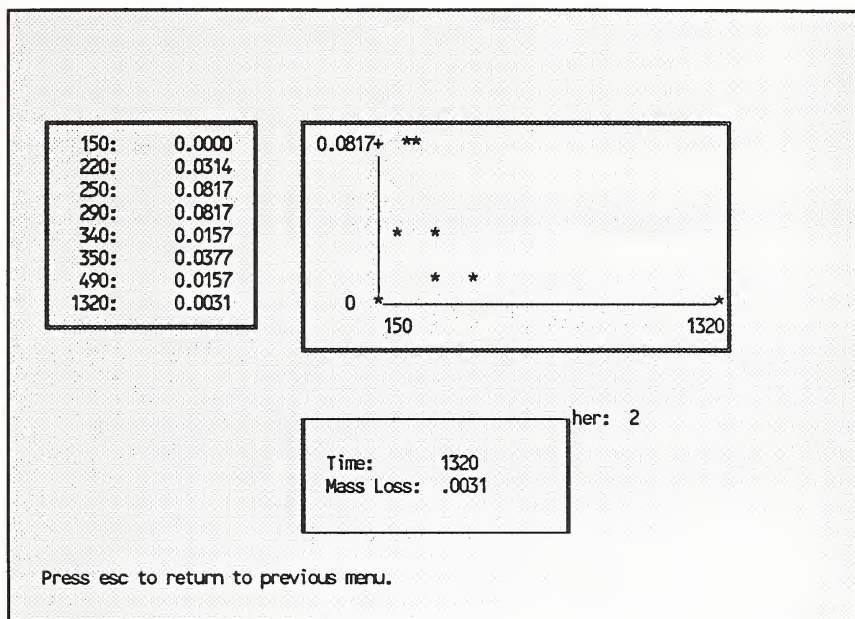
To enter each of the curves, select the appropriate quantity with the arrow keys or the mouse and press **enter**. Begin with the mass loss curve and define the timeline and mass loss curve. For the first entry, change the default entry (0 sec and 0 mass loss rate) by positioning the highlighted selection bar over the desired entry and pressing **enter**. Type 150 and 0. each followed by an **enter** to define the first time point for the kitchen cabinets. For the seven additional time points, use the **ADD** key, **f4**, to add an entry and enter the appropriate time and mass loss rate. Once the entry for a single quantity is complete, just press **esc** to return to the quantity selection menu, select another quantity and press **enter** to define values for the quantity.

For the CO, CO_2, and soot yields, you will just change the yield values for each time point (initially zero). Once you have defined the time curve for with the mass loss rate, the other quantities for the item use the same time curve. You do not have to re-enter the time curve for each species. For any single entry,

position the highlighted menu selection over the desired time point and press **enter.** Since the time points are correct, press **enter** again to move to the yield entry and type the correct value for the species and time of interest. Once all of the values for the kitchen cabinets have been entered, press **esc** to return to the main program screen.

```
                          MLTFUEL Version 2.0

     Burning Item        Burn Time          Quantities Included

     Cooking Oil         0  to  5           MDOT
     Kitchen Cabinet     150  to  1320      MDOT CO   CO2   C






     Cooking Oil
     Kitchen Cabinet
```

To view the effective mass loss rate and species yields, press the **VIEW** key, **f7**. Once you are satisfied with this composite fuel, the results may be printed using the **PRNT** key, **f8**. Since the time line, mass loss rates, and species yields are not saved on disk and must be manually input into the Fire Specification in FAST_in, you should print or copy down the values for the composite fuel. The calculated values shown on the **VIEW** screen and as printed on a printer are

shown below. The outcome of the fire can be very sensitive to the fire modeled as specified from these values. The ignition delay, mass loss rates, and species yields used for the fire specification can all affect the predicted results. Keeping a record by printing the results or copying down the results from the **VIEW** screen will allow you to study the effects of changes in future simulations.

MLTFUEL Version 2.0

Average Heat of Combustion = 27950

Time	MDot	H/C	CO/CO2	C/CO2	HCN	HCL	Ct
0	0.0000		0.0000	0.0000			
5	0.0042		0.0000	0.0000			
150	0.0042		0.0000	0.0000			
220	0.0220		0.2344	0.0500			
250	0.0506		0.1339	0.0311			
290	0.0506		0.1339	0.0311			
340	0.0131		0.0159	0.0000			
350	0.0256		0.0312	0.0000			
490	0.0131		0.0633	0.0000			
1320	0.0059		0.0000	0.0000			

Press esc to return to previous menu.

If the list is longer than can be viewed within the window, it can be scrolled by pressing the **Page Up, Page Down,** or arrow keys. The complete list will be automatically printed, along with the input data, as shown below for the present

example. Pressing the esc key and the exit key (f10) will return the user to the shell.

Note that the effective mass loss rate and species yields are calculated with an average heat of combustion for the composite fuel. Thus, the total mass loss rate is not just the summation of the individual rates.

MLTFUEL Version 2.0

Composite Fuel

    Item 1 : Cooking Oil
    Item 2 : Kitchen Cabinets
    Number of time intervals: 9

    Average Heat of Combustion = 27950

Time	MDot	H/C	CO/CO2	C/CO2	HCN	HCL	Ct
0	0.0000		0.0000	0.0000			
5	0.0042		0.0000	0.0000			
150	0.0042		0.0000	0.0000			
220	0.0220		0.2344	0.0500			
250	0.0506		0.1344	0.0311			
290	0.0506		0.1344	0.0311			
340	0.0131		0.0159	0.0000			
350	0.0256		0.0312	0.0000			
490	0.0131		0.0633	0.0000			
1320	0.0059		0.0000	0.0000			

Individual Items

    Item 1 : Cooking Oil

    Heat of Combustion = 40000

Time	Mdot	H	CO	CO2	C	HCN	HCL	Ct
0	0.0000							
5	0.0029							

Item 2 : Kitchen Cabinets

Heat of Combustion = 15900

Time	Mdot	H	CO	CO2	C	HCN	HCL	Ct
150	0.0000		0.0000	0.0000	0.0000			
220	0.0314		0.0750	0.3200	0.0160			
250	0.0817		0.0820	0.6100	0.0190			
290	0.0817		0.0820	0.6100	0.0190			
340	0.0157		0.0240	1.5100	0.0000			
350	0.0377		0.0290	0.9300	0.0000			
490	0.0157		0.0380	0.6000	0.0000			
1320	0.0031		0.0000	0.7900	0.0000			

3.5.3 FAST_in

Normally, you would have to enter all of the information for the scenario into FAST_in to create and input data file for the FAST module. Since this is one of the pre-worked examples, we can skip this step and use the data file supplied with HAZARD I.

We learned how to use FAST_in in the previous chapter, so we will move quickly through this step. Start FAST_in and select SCEN-2.DAT from the files list. Set the **DUMP INTERVAL** and **DISPLAY INTERVAL** on the **Overview** screen to **60** s each, to update the dump file and run-time graphics every minute. For this 1500 s simulation, this will result in 25 display intervals. (The maximum number of display intervals allowed is 50.) Now use the **Navigation window (f1)** to jump to the **Fire Specification** screen and see how the data which we just obtained with MLTFUEL was used by FAST_in. **Page Down** to the **Calculate** screen. Now set the dump file name to SCEN-2.DMP, turn on the **Run time graphics (f6)**, and save the file (f7) to the existing file name. **Quit** FAST_in with **f10**.

3.5.4 FAST

Without changing the default input and output filenames (SCEN-2.DAT and SCEN-2.FST) respectively, begin the simulation run. With the run time graphics turned on, you will be able to follow the results by the graphic presentation. When FAST finishes, the screen will clear and you can press **esc** to return to the shell.

It is important to note that the model simulation can take a significant amount of time. Depending upon the speed of the computer running the simulation, this time can range from 20 min (on a 33MHz 80486 system) to nearly a day (on a standard 4.77 MHz PC). The time of simulation is a function of many variables. Usually, shorter simulation times can be realized by limiting the number of rooms or vents and the simulation time.

3.5.5 FASTplot

The dump file created by FAST is unique, and can only be read by modules of HAZARD I. FASTplot is an interface to these files, allowing you to select variables of interest from the large number predicted by FAST (as many as 450 separate variables can be predicted). Once the items of interest have been ADDed to a working list, they can be PLOTted, LISTed to the screen, printer, or a file in any of several formats.

In this section, we will demonstrate some of the basic plotting operations using FASTplot. Refer to the chapter 4 of this guide for instructions on the more advanced features. Begin FASTplot from the shell by selecting it from the third menu.

Before data can be presented with FASTplot, the data must first be read from the FAST dump file created in the last section. Two steps are necessary to achieve this end. Select a dump file by typing

```
FILE SCEN-2.DMP
```

and pressing **enter**. FASTplot responds by identifying the file as a FAST dump file.

```
FASTplot Version 3.6.4, 05 Dec 1988
Command > FILE SCEN-2.DMP

Fast V18.3 Created  8/31/88,  Run 12/8/88

Command > ADD TE,TE,TE,TE,TE,TE
What compartment number (1 ... 7) for Temperature   1
And which layer U
Variable matched to Temperature  in compartment  1, layer=U

What compartment number (1 ... 7) for Temperature  2
And which layer U
Variable matched to Temperature  in compartment  2, layer=U

What compartment number (1 ... 7) for Temperature  3
And which layer U
Variable matched to Temperature  in compartment  3, layer=U

What compartment number (1 ... 7) for Temperature  4
And which layer U
Variable matched to Temperature  in compartment  4, layer=U

What compartment number (1 ... 7) for Temperature  5
And which layer U
Variable matched to Temperature  in compartment  5, layer=U

What compartment number (1 ... 7) for Temperature  6
And which layer U
Variable matched to Temperature  in compartment  6, layer=U

Enter variable(s) to add to the list:
<ENTER> To initiate read

Now reading in the data values.....
The largest possible step is    26
```

The **ADD** command is used to select variables from the file to be added to the working list of variables which can be displayed by FASTplot. Begin by **ADD**ing upper layer temperature in each room to the working list by typing

```
        ADD TE,TE,TE,TE,TE,TE
```

and pressing **enter**. The abbreviation TE is used for layer temperature. For each room in the simulation (six plus the outdoors in this example), you are prompted for a room number and a layer (Upper or Lower). Once all the variables have been ADDed to the working list, pressing **enter** once again begins the read of the variables from the FAST dump file. Many other variables can be added in this manner. To see a the possible variables which can be added, type VAR followed by an **enter** to see the list.

Add interface height to the working list for each room using the keyword INTE in the same manner as was done above to add the temperature variables. Since interface height is layer independent, you will be prompted only for a room number for each variable.

Command > VAR

Here are the possible variables for processing:

vent flow	Vent	kg/s
vent entrainment	Jet	kg/s
radiation field to a target	Target	W/m**2
heat release in flame out a vent	Vfire	kW
heat release rate of the fire	Heat release	kW
total radiative heat flux into the layer	Radiation	W
total convective heat flux into the layer	Convection	W
pyrolysis rate of the fuel	Pyrolysis	kg/s
mass flux from the plume into the upper layer	Plume	kg/s
entrained mass flow in the plume	Entrain	kg/s
hcl wall surface concentration	Hcl	
pressure	Pressure	Pa
heat release in lower layer	Lplume	kW
heat release in upper layer	Uplume	kW
wall surface temperature	Wall	C
layer temperature	Temperature	C
volume of the upper layer	Volume	m**3
layer mass density	Mass	kg/m**3
species density	Species	as appro.
layer height	Interface	m

Once the working list has been established, the variables in the list may be displayed as a list or as a graph. To display as a graph, the PLOT command is used

```
Command > PLOT
  The present list is as follows:
   # Variable    Comp Lay Spec      File
  --------------------------------------------------
   1  Temperature   1  U        SCEN-2.DMP
   2  Temperature   2  U            "
   3  Temperature   3  U            "
   4  Temperature   4  U            "
   5  Temperature   5  U            "
   6  Temperature   6  U            "
   7  Interface     1  U            "
   8  Interface     2  U            "
   9  Interface     3  U            "
  10  Interface     4  U            "
  11  Interface     5  U            "
  12  Interface     6  U            "

  Select 1->4 graphs by grouping variables
  with parentheses followed by <RETURN> (1 2 3 4 5 6)
```

Once a list of the variables on the working list is displayed, the variables to be plotted are selected by grouping variable numbers from the left hand column of the list in up to four parenthetical groups to producing up to four graphs on a single screen. For now, let's just display all of the upper layer temperatures on a single graph by entering

(1 2 3 4 5 6)

at the prompt. The resulting graph is displayed on the screen and shown on page 82. The graph shows the upper layer temperature in all six room of the building (labeled as 1U to 6U for Room 1, Upper layer, etc.). The axes are labeled to indicate time in seconds (Time (s)) and layer temperature in degrees celsius (T_{Layer} (C)). Normally, these labels and the scales of the axes are determined automatically. Press enter once you have examined the graph to

return to the FASTplot command prompt. Note that all of the curves displayed are in the same units. Quantities with different units cannot be displayed on the same graph – so you could not display temperature and gas concentration on the same graph.

For certain printers, a utility program called METAPRNT is provided which allows you to print copies of the graph on the screen. Details of the use of the utility is provided in the FASTplot section of chapter 4 in this **Software User's Guide**.
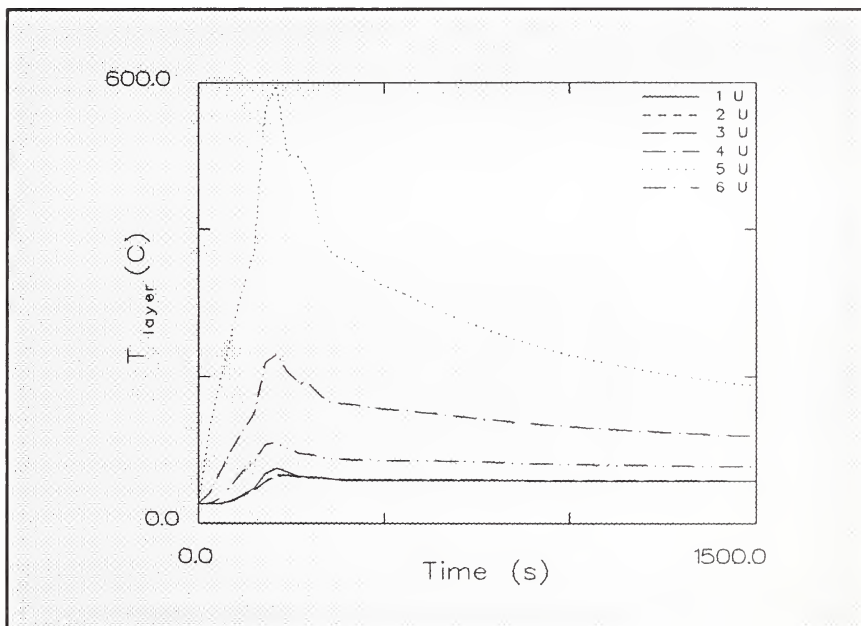
To view the variables as a table of numbers, the LIST command is used. A table of up to five columns can be produced. After typing **LIST**, you will be presented with a list of the variables and prompted for the variables to be

LISTed and the beginning and ending times to be listed. Just like the PLOT command, enter the variable numbers such as

    1 2 7 8

to list upper layer temperatures and interface heights in rooms 1 and 2 in the example. Beginning and ending times are specified as time steps. Each time step corresponds to the interval between successive data points in the FAST dump file. To list the first 20 time steps, enter 0 20 at the prompt. Finally, the **END** command is used to exit FASTplot and return to the shell.

As a final example, we will create a four-graph display. Begin FASTplot anew from the shell and select the file **SCEN-2.DMP**. Add seven variables to the working list as follows

       Upper layer **TE**mperature in room 1
       Upper layer **TE**mperature in room 5
       INTErface height in room 1
       INTErface height in room 5
       HEAT release rate in the upper layer in room 5
       The **SPEC**ies CO_2 in the upper layer in room 1
       The **SPEC**ies CO_2 in the upper layer in room 5

Generate the plot with the **PLOT** command by placing the variables in four groups with the plot specified as (1 2)(3 4)(5)(6 7). The four graphs produced are shown below. Return to the shell with **END**.

```
Command > LIST
The present list is as follows:
 #  Variable     Comp Lay Spec      File
-------------------------------------------------
 1  Temperature   1  U          SCEN-2.DMP
 2  Temperature   2  U             "
 3  Temperature   3  U             "
 4  Temperature   4  U             "
 5  Temperature   5  U             "
 6  Temperature   6  U             "
 7  Interface     1  U             "
 8  Interface     2  U             "
 9  Interface     3  U             "
10  Interface     4  U             "
11  Interface     5  U             "
12  Interface     6  U             "

The maximum number of variables allowed is 5.
List the variables for output 1 2 7 8
Time steps go from 0 to   25
Enter time interval desired (<ENTER> for entire duration) 0 9

 Time (s)   Temperature    Temperature    Interface      Interface
 L,S,F->T   U, 0,0->0      U, 0,0->0      U, 0,0->0      U, 0,0->0
   0.          27.0           27.0           2.40           2.40
  60.          27.1           27.1           1.69           2.39
 120.          39.5           38.1           1.05           1.49
 180.          68.5           57.2           0.838          0.471
 240.          70.7           65.9           0.433          0.204
 300.          63.7           62.8           0.172          3.424E-02
 360.          60.7           60.7           0.378          8.491E-03
 420.          59.4           59.8           0.227          8.679E-03
 480.          59.4           59.7           0.307          1.023E-02
 540.          59.2           59.7           0.364          9.739E-03

Command > END
```
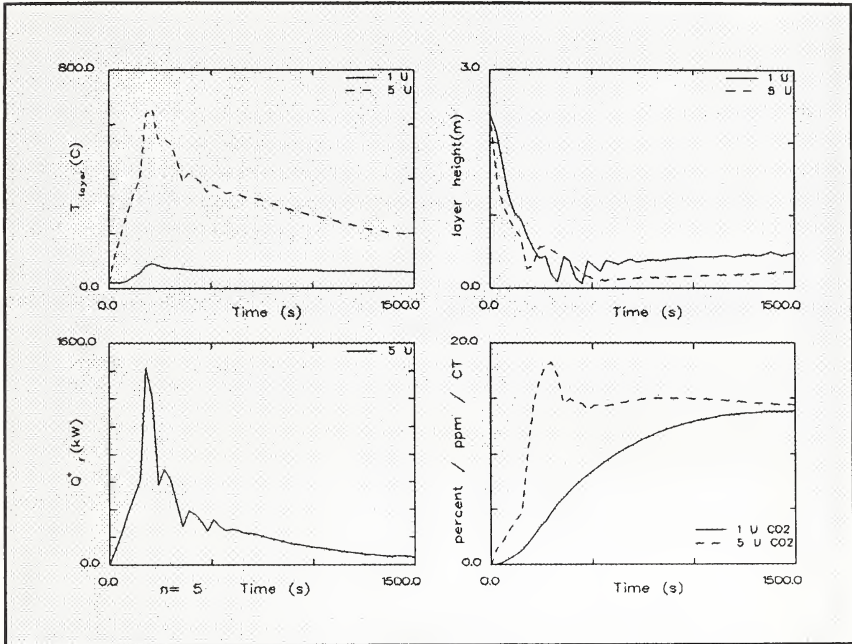
3.5.6 EXITT

EXITT is used to provide estimates of building evacuation times. Two DOS files provide the necessary inputs to EXITT. The first, a FAST dump file, was produced above by the FAST model execution in section 3.5.4. The second describes the building and occupants and is created by the user using an ASCII text editor such as the one built into the shell.

3.5.6.1 Completing the Building Worksheets

The details of creating the file which contains the node map of the building and the description of the occupant set is provided in section 4.3. To create the file, the movement paths through the building are defined as a series of nodes (a node is a room, a location in a room, a door, or a window) connected by a series of paths which define the allowable movements throughout the building (and thus the distances between adjacent nodes). For this example, we will develop (and thus replicate) the supplied example file for the test case, the DOS file SCEN-2.BLD. All of the building and occupant descriptions are detailed in the Examples Cases section of the Technical Reference Guide.

The following information is required to create the building / occupant file for EXITT:

1. number of rooms modeled by FAST in the fire simulation,
2. number of actual rooms in the building,
3. the series of nodes described above,
4. the floor to ceiling height and floor height at each node,
5. the background noise level at each node,
6. location of smoke detectors and the loudness of the detectors at each node,
7. the interconnection of these nodes (which nodes are connected and the distances between adjacent nodes),
8. a description of the occupants in the building (age, sex, and capability to escape).

Each of these items will be covered in detail below. A series of worksheets are included as Appendix A to aid in the development of this information for the building / occupant file.

In the FAST simulation of the fire in this ranch house, the master bedroom and master bath, the hallway and hall bath, and the living room and dining room were each combined into a single room to allow the fire to be simulated with a total of six rooms. Since EXITT does not have this six room limitation, we can
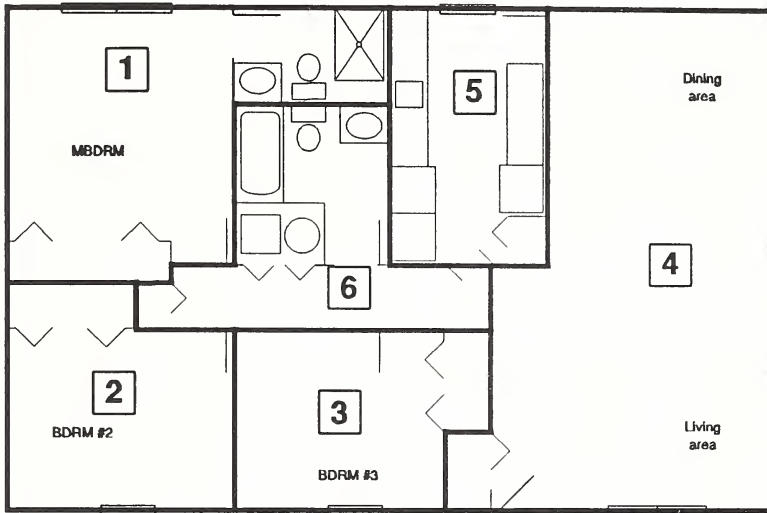
Figure 4. FAST room layout for kitchen cabinet fire example.

resort to the full building description for the EXITT simulation. Figure 5 shows the building layout with the FAST rooms outlined. In addition, Figure 5 shows the building layout with the EXITT rooms outlined. In both figures, the rooms number assigned are noted. Although you may number the rooms with some flexibility, it is usually appropriate to number the two sets of "rooms" with similar notation. In this example, the six FAST rooms are numbered 1 through 6 in the EXITT notation. The master bath, hallway, and dining room were number 7, 8, and 9 respectively.

To develop the travel paths through the building, start with the EXITT room layout (Figure 5), and place a node in each room, a node at each interior doorway, and a node at each window or doorway to the outdoors. Figure 6 shows the nodes place throughout the building. These are assumed to be the various paths which may be traveled during the simulation of building egress by

Figure 5. EXITT room layout for kitchen cabinet fire example.

EXITT. Note that nodes 1 to 9 correspond to the center of each EXITT room (with the same numbering as the EXITT rooms), nodes 10 to 14 are the interior doorways, and nodes 15 to 21 are the windows and doorways to the outdoors. The nodes are simply numbered sequentially from 1 to 21. Since the building is a one-story house, the ceiling height and floor height are constant for all nodes at 2.4 m and 0.0 m respectively.

To complete the Building Node Worksheet, we also need information on smoke detectors in the building. In this example, we assume a single smoke detector in the center of the hallway. We will let EXITT determine the smoke detector activation time. Using the guidelines in section 4.3, the loudness of the detector at each node is calculated. The completed Building Node Worksheet for this example is shown on page 88.
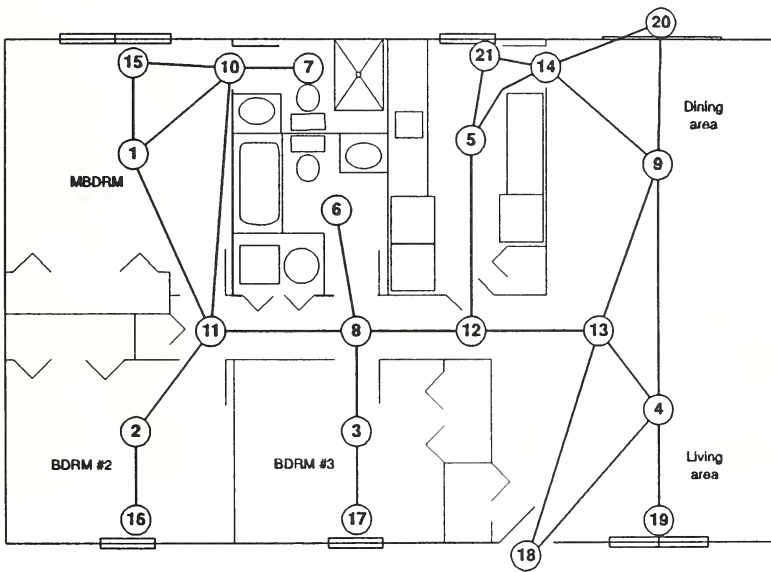
Figure 6. Travel paths through building for kitchen cabinet fire example.

Table 2. Building Node Worksheet for EXITT example

BLD File Name: SCEN-2.BLD
FAST Rooms: 6   Nodes: 21
Detector Node Number: 9   Activation Time[a]: -1

EXITT Node Number	EXITT Room Number	FAST Room Number[b]	Node Height[c] (m)	Floor Height[d] (m)	Ambient Noise[d]	Detector Loudness[d]
1	1	1	2.4	0.	35	71
2	2	2	2.4	0.	35	
3	3	3	2.4	0.	35	
4	4	4	2.4	0.	35	
5	5	5	2.4	0.	35	
6	6	6	2.4	0.	35	
7	7	1	2.4	0.	35	
8	8	4	2.4	0.		
9	9	6	2.4	0.		
10	1	1	2.4	0.		
11	9	6	2.4	0.		
12	9	6	2.4	0.		
13	4	4	2.4	0.		
14	8	8	2.4	0.		
15	1	8	2.4	0.		
16	2	8	2.4	0.		
17	3	7	2.4	0.		

Table 2. Building Node Worksheet for EXITT example (continued)

a - enter -1 for program to determine detector activation time.
b - enter the FAST room number if not a door or window,
　 # of FAST room + 1 if node is a door,
　 # of FAST room + 2 if node is a window.
c - enter floor to ceiling height at the node.
d - at the node.

To determine the travel paths throughout the building, refer to the node layout diagram (Figure 6). Each line connecting two nodes (an edge) must be entered once and only once. For our example, this is a total of 26 edges. Beginning with node number 1, we note it is connected to nodes 10, 11, and 15. These are shown in the first three entries of the worksheet on page . Similarly, node number 2 is connected to nodes 11 and 16. The rest of the Building Travel Paths Worksheet is completed in a similar manner. Enter only edges which connect to a higher numbered node to insure each edge is counted only once. For example, for node 13, only the edge from node 13 to node 18 is entered. The other edges should have been already entered with nodes 4, 9, and 12.

Table 3. Building Travel Paths Worksheet for EXITT example

Number of Edges: _____ 27 _____

First Node Connected to Edge (must be a node on the Building Node Worksheet)	Second Node Connected to Edge (must be a node on the Building Node Worksheet)	Travel Distance Between Nodes (m)
1	10	1.89
1	11	3.41
1	15	1.83
2	11	2.71
2	16	1.52
3	9	2.13
3	17	1.52

Table 3. Building Travel Paths Worksheet for EXITT example (continued)

4	8	4.27
4	13	2.38
4	18	3.13
4	19	2.13
5	12	2.74
5	14	3.35
5	21	2.13
6	9	2.51
7	10	1.68
8	11	2.06
8	12	2.44
9	13	3.30
9	14	2.05
9	20	2.13
10	11	4.27
10	15	1.57
12	13	1.37
13	18	3.69
14	20	1.50
14	21	1.93

Since occupant characteristics in homes are extremely variable, it is decided that a mixed family composition should be used to represent the range of characteristics which might be expected.

The family members selected include:

> The father, aged 30, located in the master bathroom.
> The mother, aged 30, in the hall.
> A daughter, aged 7, in the living room watching TV.
> A son, aged 5, watching TV with his sister.
> A grandmother, aged 71, in bedroom 3.

All occupants are assumed to be awake and fully capable at the time of the fire. The completed Building Occupant Worksheet is shown below.

Table 4. Building Occupant Worksheet for EXITT example

Number of Occupants: _____5_____

Occupant Number	Age	Sex[a]	Awake or Asleep[b]	Initial Node Location	Assistance required[c]	Sleeping Penalty[d]	Travel Speed[e] (m/s)
1	30	1	1	7	0	0.	-1.
2	30	0	1	8	0	0.	-1.
3	71	0	1	3	0	0.	-1.
4	7	0	1	4	0	0.	-1.
5	5	1	1	4	0	0.	-1.

3.5.6.2 Creating the EXITT Building / Occupant File

Information from the three worksheets completed above is entered using an ASCII text editor such as the one included as part of the HAZARD I shell. Columns of the worksheets are entered as follows:

EXITT Keyword	Column(s) Entered
ROOMS	Number of FAST rooms and number of nodes from Building Node Worksheet
NODESTOFAST	3 of Building Node Worksheet
NODESTOEXITT	2 of Building Node Worksheet
NODEHGT	4 of Building Node Worksheet
FLRHGT	5 of Building Node Worksheet
AMBNOISE	6 of Building Node Worksheet
DETECTORS	Number of detectors, detector activation time, and detector location from Building Node Worksheet followed by column 7 of Building Node Worksheet
NODETONODE	Number of edges from Building Travel Paths Worksheet followed by each row from Building Travel Paths Worksheet
OCCUPANTS	Number of occupants from Building Occupant Worksheet followed by each column from Building Occupant Worksheet

Since the file already exists as SCEN-2.BLD, we will use this for the example. The completed input file, taken directly from the columns of the three tables is shown below and included with the HAZARD I software.

```
ROOMS 6 21
NODESTOFAST 1 2 3 4 5 6 1 4 6 1 6 6 4 4 8 8 8 7 8 7 8
NODESTOEXITT 1 2 3 4 5 6 7 9 8 1 8 8 4 9 1 2 3 4 4 9 5
NODEHGT 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4
        2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4
FLRHGT  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
```

```
        0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
AMBNOISE 35 35 35 35 35 35 35 55 35 35 35 35 55 55 35 35 35 35 35 55 35
DETECTORS 1 -9 9
         71 83 71 83 83 83 59 83 95 71 95 95 83 83 71 83 71 83 83 83 83
NODETONODE 27
 1 10 1.89      1 11 3.41      1 15 1.83
 2 11 2.71      2 16 1.52
 3  9 2.13      3 17 1.52
 4  8 4.27      4 13 2.38      4 18 3.13      4 19 2.13
 5 12 2.74      5 14 3.35      5 21 2.13
 6  9 2.51
 7 10 1.68
 8 13 3.30      8 14 2.05      8 20 2.13
 9 11 2.06      9 12 2.44
10 11 4.27     10 15 1.57
12 13 1.57
13 18 3.69
14 20 1.50     14 21 1.93
OCCUPANTS 5
30 30 71 7 5
1 0 0 0 1
1 1 1 1 1
7 9 3 4 4
0 0 0 0 0
0. 0. 0. 0. 0.
-1. -1. -1. -1. -1.
```

3.5.6.3 Running EXITT

Begin EXITT by selecting it from the shell. You will be presented with at least five prompts: two (or more) prompts for FAST dump files (FAST can generate multiple dump files for a single fire by using the RESTRT option as described in chapter 4), one prompt for the Building / Occupant file, one prompt for the printed output from EXITT, and one prompt for the EXITT dump file (which automatically passes the results of the EXITT run to TENAB for tenability analysis). The responses for the five prompts are shown below.

FAST dump file 1:	SCEN-2.DMP
FAST dump file 2:	just press enter
Building/Occupant file:	SCEN-2.BLD
EXITT output file:	SCEN-2.EXT
EXITT dump file:	SCEN-2.EVA

```
EXITT Version:  18.1 - Creation Date:  2/09/89 - Run Date:  4/01/89

The set of FAST dump       files in the current directory are:
SCEN-1.DMP     SCEN-2.DMP     SCEN-3.DMP     SCEN-4.DMP     SCEN-5.DMP
SCEN-6.DMP     SCEN-7.DMP     SCEN-8.DMP

Enter the FAST dump file name - Hit RETURN when no more FAST files
To CANCEL enter:/CANCEL SCEN-2.DMP

The set of FAST dump       files in the current directory are:
SCEN-1.DMP     SCEN-2.DMP     SCEN-3.DMP     SCEN-4.DMP     SCEN-5.DMP
SCEN-6.DMP     SCEN-7.DMP     SCEN-8.DMP

Enter the FAST dump file name - Hit RETURN when no more FAST files
To CANCEL enter:/CANCEL

The set of BUILDING-OCCUPANT files in the current directory are:
SCEN-1.BLD     SCEN-2.BLD     SCEN-3.BLD     SCEN-4.BLD     SCEN-5.BLD
SCEN-6.BLD     SCEN-7.BLD     SCEN-8.BLD

Enter the BUILDING file name
To CANCEL enter:/CANCEL SCEN-2.BLD


Enter the EXITT output file name
To CANCEL enter:/CANCEL SCEN-2.EXT


Enter the EXITT dump file name
To CANCEL enter:/CANCEL SCEN-2.EVA

Simulation completed
```

Return to the shell by pressing esc. The results of the EXITT simulation are written to the file SCEN-2.EXT. This file may be viewed by pressing the **VIEW** key, **f7** and entering the name of the file, SCEN-2.EXT. Use the **Page Up** and **Page Down** keys to browse through the file to examine the results of the simulation.

The output from EXITT (for example, stored here in the file SCEN-2.EXT) is divided into a number of sections. The first several sections simply reproduce the data from the building file developed by the user. The remaining sections

show the results of the calculation, grouped to show all of the actions for each occupant of the building. An excerpt from the example is shown below.

```
ACTIONS TAKEN BY PERSON   1
NODE ROOM  TIME  SAV- SAVED DESTI- ACTION
                 ING   BY  NATION
   7   1   0.0   --    --    --    INITIAL POSITION
   7   1  166.0  --    --     5    INVESTIGATE FIRE
  10   1  167.3  --    --     5    ARRIVE AT NEW NODE
  11   6  170.6  --    --     5    ARRIVE AT NEW NODE
  11   6  171.6  --    --    --    ALERTED BY ANOTHER - END INVESTIGATION
  11   6  173.6  --    --    --    LEAVE BUILDING
   9   6  174.8  --    --    18    ARRIVE AT NEW NODE
  12   6  176.2  --    --    18    ARRIVE AT NEW NODE
  13   4  177.2  --    --    18    ARRIVE AT NEW NODE
  18   7  179.4  --    --    18    LEAVE BUILDING THROUGH DOOR
```

Each line of the output shows the location (*NODE* and *ROOM* number), *TIME*, who was being assisted by the occupant (*SAVING*), who was assisting the occupant (*SAVED BY*), where the occupant decided to go (a *DESTINATION* node number), and the *ACTION* the occupant decided upon. Note that at this point, we simply know the path each occupant would take during an escape. The effects of the fire on the occupants (i.e., their ability to escape the fire without becoming incapacitated or dying) are determined by TENAB.

3.5.7 TENAB

TENAB follows a person's escape route through a building as determined by EXITT, and for each occupant, determines several tenability measures based upon the person's exposure to hazardous conditions. TENAB requires two input files and creates two output files. The first, a FAST dump file, was produced above by the FAST model execution in section 3.6. The second, an EXITT dump file was produced by the EXITT model execution in section 3.8.

Begin TENAB by selecting it from the shell. You will be presented with five prompts: two prompts for FAST dump files (since FAST can generate multiple

dump files to represent a single fire with the RESTRT option), one prompt for the EXITT dump file, one prompt for the printed output from TENAB, and one prompt for the TENAB dump file (which automatically passes the results of the TENAB run to FASTplot for display). The responses for the five prompts are shown below and on the screen on the next page.

FAST dump file 1:	SCEN-2.DMP
FAST dump file 2:	just press **enter**
EXITT dump file:	SCEN-2.EVA
TENAB output file:	SCEN-2.TEN
TENAB dump file:	SCEN-2.PLT

Return to the shell by pressing **esc**. The results of the TENAB simulation are written to the file SCEN-2.TEN. This file may be viewed by pressing the **VIEW** key (**f7**) and entering the name of the file, SCEN-2.TEN. Use the **Page Up** and **Page Down** keys to browse through the file to examine the results of the simulation. The file may be printed by pressing the **PRNT** key, **f8**.

Like EXITT, the output from TENAB (stored here in the file SCEN-2.TEN) is divided into a number of sections. The first several sections simply reproduces the data calculated by EXITT. The remaining sections show the results of the calculation, grouped to show the effects for each occupant. An excerpt from the example is shown below.

```
PERSON  3
   TIME NODE  CONDITION     CAUSE   FED1        TEMP1      CT          FLUX
                                    FED2        TEMP2
                                    FED3
   (SEC)                                                   (G-MIN/M3) (KW-SEC/M2)
    180.  13  INCAPACITATED TEMP1 0.000E+00  0.960E+02  0.101E+01  0.537E+01
                                    0.168E-02  0.282E-02
                                    0.642E-02
    180.  18  ESCAPE               0.000E+00  0.960E+02  0.101E+01  0.537E+01
                                    0.168E-02  0.282E-02
                                    0.642E-02
   1500.  18  FINAL TIME           0.000E+00  0.960E+02  0.101E+01  0.537E+01
                                    0.168E-02  0.282E-02
                                    0.642E-02
```

At each time interval, TENAB determines for each occupant of the building the current room being occupied and the layer to which the occupant is exposed. From this information, the average layer temperature of the room, the fractional exposure doses, the flux and integrated concentration-time product are computed. If the FED, FEDP, FEDCO2, FEDTEMP, TEMPA, or CT for a particular occupant exceeds the "critical" incapacitation level, or if the FLUX exceeds the corresponding tenability limit then the occupant is considered incapacitated. If the FED, TEMP or CT for a particular occupant exceeds the "critical" lethality level, then the occupant is considered dead. When an occupant exits the building, reaches a window, becomes incapacitated or dies, the program records the time, the room, the occupant's condition, the cause, and the levels of FED, FEDP, FEDCO2, FEDTEMP, TEMPA, CT, and FLUX. The meaning and limits for each of these criteria are described in sections 6 and 7 of the Technical Reference Guide.

3.6 Evaluating the Consequences

Once the consequences of the specified scenario have been calculated, the user must interpret the results. This is the last step in the overall process. Depending on the application, the user typically will run additional cases/scenarios and compare results. For example, calculated consequences may be compared with previously worked or representative cases. Alternatively, the user may run scenarios with and without the product in question to quantify the difference in consequences/losses. Finally, variations in product properties may be assessed in successive calculations.

For the present example, the approach used is to run scenarios with and without the new product. Therefore, we now go back to MLTFUEL to reduce the pyrolysis rate of the cabinets by half (remember to recalculate the yield ratios as the results will change). Then enter the new data into FAST_in (on the **Fire Specification** screen), append the graphics file (**f6** on the **Calculate** screen) and save the modified file with a new name (we used SCEN-2<u>M</u> for <u>M</u>odified).

```
TENAB Version:  18.1 - Creation Date:  2/09/89 - Run Date:  4/01/89

The set of FAST dump         files in the current directory are:
SCEN-1.DMP      SCEN-2.DMP      SCEN-3.DMP      SCEN-4.DMP      SCEN-5.DMP
SCEN-6.DMP      SCEN-7.DMP      SCEN-8.DMP

Enter the FAST dump file name - Hit RETURN when no more FAST files
To CANCEL enter:/CANCEL SCEN-2.DMP

The set of FAST dump         files in the current directory are:
SCEN-1.DMP      SCEN-2.DMP      SCEN-3.DMP      SCEN-4.DMP      SCEN-5.DMP
SCEN-6.DMP      SCEN-7.DMP      SCEN-8.DMP

Enter the FAST dump file name - Hit RETURN when no more FAST files
To CANCEL enter:/CANCEL

The set of EXITT dump        files in the current directory are:
SCEN-1.EVA      SCEN-2.EVA      SCEN-3.EVA      SCEN-4.EVA      SCEN-5.EVA
SCEN-6.EVA      SCEN-7.EVA      SCEN-8.EVA

Enter the EXITT dump file name created by EXITT - If none hit RETURN
To CANCEL enter:/CANCEL SCEN-2.EVA


Enter the TENAB output file name
To CANCEL enter:/CANCEL SCEN-2.TEN


Enter the TENAB dump file name
To CANCEL enter:/CANCEL SCEN-2.PLT

TENAB output being written to file: SCEN-2.TEN

TENAB dump file being written to file: SCEN-2.PLT
```

Repeating each step followed in the original scenario will produce the same final result, that the occupants successfully escape. A better (and more general) way to evaluate the differences in the products is to compare the time to hazards for each room. (This is discussed in the **Technical Reference Guide**.) This is done by manual input of EXITT data into TENAB as described in chapter 4 and shown on the next two pages. When asked for an EXITT dump file, enter **con** and you will be prompted for the data after all of the file names have been

entered. The number of nodes is 6 (one for each room). The next six lines are of the form **1,1,0,0; 2,2,0,0;** etc. (for person **1**, in room **1**, at time **0**, standing at height **0**). Just press **enter** to indicate the end of data input.

```
Enter the EXITT dump file name
To CANCEL enter:/CANCEL con

Enter the TENAB output file name
To CANCEL enter:/CANCEL SCEN-2M.TEN

Enter the TENAB dump file name
To CANCEL enter:/CANCEL SCEN-2M.PLT

Enter the number of nodes (including doors and windows)
FAST was run with  6 rooms 6

Enter occupant no, node no, time (sec), floor elevation of node
When done just press the enter key
1 1 0 0

Enter occupant no, node no, time (sec), floor elevation of node
When done just press the enter key
2 2 0 0

Enter occupant no, node no, time (sec), floor elevation of node
When done just press the enter key
3 3 0 0

Enter occupant no, node no, time (sec), floor elevation of node
When done just press the enter key
4 4 0 0

Enter occupant no, node no, time (sec), floor elevation of node
When done just press the enter key
5 5 0 0

Enter occupant no, node no, time (sec), floor elevation of node
When done just press the enter key
6 6 0 0

Enter occupant no, node no, time (sec), floor elevation of node
When done just press the enter key

The number of room run with FAST is  6
The outside is considered "room"  7 by FAST
At a window is considered "room"  8 by FAST
The number of nodes run with EXITT is  6
```

```
Please enter the FAST room number associated with each EXITT node

FAST room number associated with EXITT node number    1 1

FAST room number associated with EXITT node number    2 2

FAST room number associated with EXITT node number    3 3

FAST room number associated with EXITT node number    4 4

FAST room number associated with EXITT node number    5 5

FAST room number associated with EXITT node number    6 6

Incapacitation Critical Values:
     1. FED(CO,CO2,O2,HCN,HAZ I BETA)...   0.50
     2. FED(CO,CO2,O2,HCN,PURSER).......   1.00
     3. FED(CO2,PURSER)................   1.00
     4. TEMP(AVERAGE, HAZ I BETA).......  65.00 (DEG C)
     5. FED(TEMPERATURE,PURSER).........   1.00
     6. CT(HAZ I BETA) ................ 450.00 (G-MIN/M3)

Lethality Critical Values:
     7. FED(CO,CO2,O2,HCN,HAZ I BETA)...   1.00
     8. TEMP(AVERAGE, HAZ I BETA)....... 100.00 (DEG C)
     9. CT(HAZ I BETA) ................ 900.00 (G-MIN/M3)

To change a value, select an option and its new value
     When done just press ENTER


TENAB output being written to file: SCEN-2M.TEN

TENAB dump file being written to file: SCEN-2M.PLT
```

Performing this analysis on both example case runs (FAST dump files SCEN-2.DMP and SCEN-2M.DMP) reveals that the cabinets constructed of the new core material delay the onset of hazardous conditions by about 30 s (out of about 3 min) for most rooms and criteria, both thermal and toxicity. Thus for this example, the trade-off of increased toxic potency (additional HCN release) for

reduced burning rate (by half) was a good one. By examining the cost differential of the two cabinet constructions, a cost-benefit ratio is obtained. Finally, you may decide to examine the sensitivity of these results to variations in some parameters or assumptions as a test of validity.

4 Software Reference

Each of the eight main programs which make up HAZARD I may be executed from the main program shell or as a stand alone program. Instructions for the use of each module are provided below with the instructions for the use of the programs divided by each major function of the program (entering data or calculating results, for instance).

4.1 HAZARD I Interface Shell

The HAZARD I shell provides an interactive, user-friendly method to access all of the modules of HAZARD I. To begin operation of the shell, just enter

    HAZARD

followed by an enter at the DOS prompt.

4.1.1 Using Dialog Boxes

Operation of the HAZARD I shell utilizes a standardized technique for all data input called the dialog box. The dialog box is simply a rectangular box presented in a standard form on the screen for data input and output. It is used extensively in many computer applications on a wide range of computers. HAZARD I makes use of several different elements within its dialog boxes – text boxes, list boxes, option buttons, check boxes, and command buttons. Use of each of these elements is described below.

Moving around within a dialog box. Press the Tab key to move forward to the next element in a dialog box. Shift-Tab moves backwards in the box. Within a group of option buttons, use the arrow keys to move from option to option.

Holding down the Alt key will highlight a set of shortcut keys which when pressed in concert with the Alt key will move directly to the desired dialog box element.

```
┌───────────────────────────────────────────────────────────────┐
│   ┌──────────────────── Create Output File ────────────────┐   │
│   │                                                          │   │
│   │   File Spec  │*.DMP                              │       │   │
│   │                                                          │   │
│   │   Output File│                                   │       │   │
│   │                                                          │   │
│   │   ┌──────────────────────────┐  ┌─────────────────────┐  │   │
│   │   │ CVENT.DMP    SCEN-2.DMP   │  │[X]Initial Conditions│  │   │
│   │   │ HCL.DMP      SCEN-3.DMP   │  │[X]Normal Output     │  │   │
│   │   │ HVAC.DMP     SCEN-4.DMP   │  │[ ]Flow Field        │  │   │
│   │   │ LOBA.DMP     SCEN-6.DMP   │  │[ ]Species           │  │   │
│   │   │ MANYVENT.DMP SCEN-7.DMP   │  │[ ]HAZARD 1 FED      │  │   │
│   │   │ SCEN-1.DMP   SCEN-8.DMP   │  │[ ]Purser FED        │  │   │
│   │   └──────────────────────────┘  └─────────────────────┘  │   │
│   │      < OK >          < Cancel >          < Help >         │   │
│   └──────────────────────────────────────────────────────────┘   │
│                                                                   │
└───────────────────────────────────────────────────────────────────┘
```

Command buttons. Command buttons direct the program to process the information in the dialog box. Typically, up to three command buttons are available on a dialog box – < OK >, < Cancel >, and < Help >. To select a command button, move to the button and press enter. In all cases, you may also press esc for < Cancel > and Alt-H or f1 for < Help >. The function of these command buttons is obvious. Selecting < OK > tells the program the information entered in the dialog box is correct and the program should proceed with the requested operation. < Cancel > directs the program to ignore the information in the dialog box and cancel the requested operation. < Help >

provides a screen of help text relevant to the current operation or dialog box item.

Text boxes. A text box is a rectangle into which you type information, usually a filename or other specification. To enter new information into a text box, just move to the text box and begin typing the information. Any text placed in the box by default is replaced by the typed information. To edit the existing information, use the arrow keys to move left or right in the text and change the information. The delete, backspace, and insert keys allow you erase or insert information into the text string.

List boxes. A list boxes shows a number of available choices from which to select a single entry. Once you have moved to a list box element, you can select a desired entry by highlighting it with the arrow keys. The Home and End keys will also move to the beginning or end of the list.

A scroll bar on the side or bottom of the box provides a visual indication of the size of the list in the box. Since not all items may be displayed on the screen for long lists, the scroll bar allows you to see, at a glance, where you are in a long list relative to the beginning and end of the list.

Option buttons (not shown in the example above). Option buttons present a list of mutually exclusive selections in a dialog box. An option button is shown as a set of parentheses – ( ). The selected option is shown with a filled circle between the parentheses – (●). To select an option, move to the desired group of options and use the arrow keys to select an option.

Check boxes. Check boxes present a list of selections, any or all of which may be selected. A check box is indicated by a set of brackets – [ ]. A selected check box is shown with an "X" between the brackets – [X]. To select or clear a check box option, move to the check box and press the spacebar to select or clear the option.

4.1.2 Running a HAZARD I Module

Operation of the shell revolves around several pulldown menus which list the major functions of HAZARD I:

- **File** (general file operations, exit, and setup)

- **Create Input Data** (FAST_in, MLTFUEL, FIREDATA, and DETACT modules)

- **Run Fire Model** (FAST module)

- **Analyze Results** (FASTplot, EXITT, and TENAB modules)

- **Help**

```
File    Create Input Data    Run Fire Model    Analyze Results         Help
┌─────────────────────┐
│ Edit File (f6)      │
│ View File (f7)      │
│ Print File (f8)     │
│ Copy File           │
├─────────────────────┤
│ Shell to DOS (f5)   │
│ Exit (f10)          │
├─────────────────────┤
│ Setup               │
└─────────────────────┘        HAZARD I Version 1.1

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```
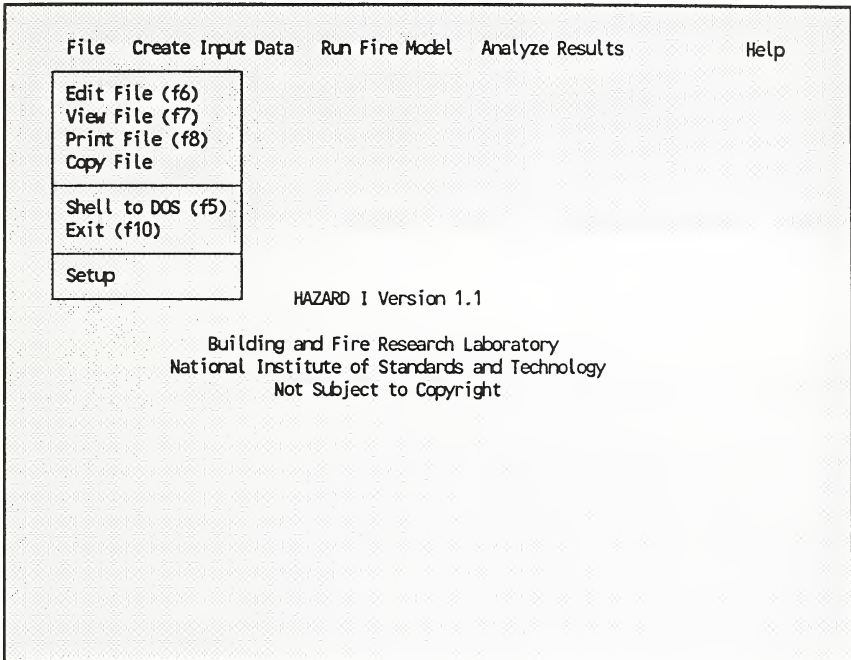
The shell allows the user to select any of the modules of HAZARD I by using the arrow keys to position the highlighted selection bar over the desired module. Use the arrow keys to move up or down to a menu item and press enter to begin operation of the desired module. With any menu selected, you may also use the arrow keys to move right or left to another menu.

```
        File    Create Input Data   Run Fire Model   Analyze Results         Help
       ┌──────────────────────┐
       │ Edit File (f6)        │
       │ View File (f7)        │
       │ Print File (f8)       │
       │ Copy File             │
       ├──────────────────────┤
       │ Shell to DOS (f5)     │
       │ Exit (f10)            │
       ├──────────────────────┤
       │ Setup                 │
       └──────────────────────┘      HAZARD I Version 1.1

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```
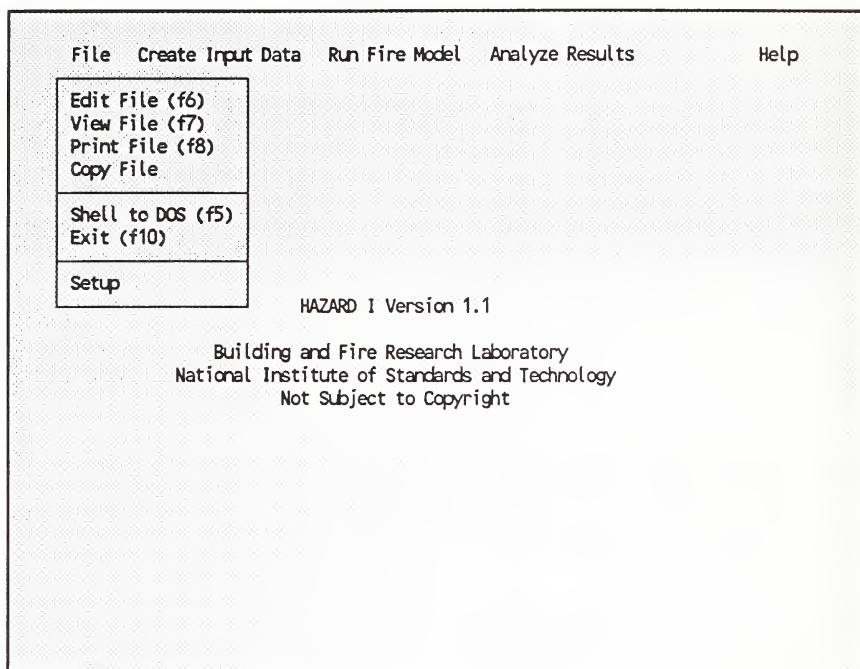
The **File** pulldown allows the user to perform a number of file operations which would normally require you to leave the program, perform the operation and re-start the program. The operations are described below.

Edit File (f6). any file up to 500 lines in length may be edited from within the shell. Press f6 and enter the name of the file to be edited. If the file does not exist, a new file will be created. Once all desired changes to the file have been made, press esc to exit the editor. If the file exists, you will then be prompted to see if the file is to be replaced (if you have made any changes). In the dialog box, you may replace the file by selecting < OK > or change the file name and select < OK > to save the file in another location.

The editor features on-line help (by pressing f1), both horizontal and vertical scrolling, as well as block operations for insert, delete, and copy. All of the standard editing keys are supported. For example, Home and End move to the beginning and end of the line, the PgUp and PgDn keys scroll the screen by pages, and Ctrl-PgUp and Ctrl-PgDn move to the first and last lines, respectively. The cursor may also be moved to the top or bottom of the edit window with the Ctrl-Home and Ctrl-End keys. The Ctrl-Left and Ctrl-Right arrow keys are used to move the cursor by words, and blocks are marked with any of the Shifted Arrow keys. Notice that blocks may also be marked using a combination of the Shift AND Ctrl arrows to jump by whole words.

Beyond the usual block operations, however, the editor also supports block operations on columns. To mark a block in sentence mode, place the cursor at the beginning of the block and press the Shift-Right arrow key. The marked block will be highlighted as the cursor travels over the text. Alternately, entire lines may be marked by placing the cursor at the desired starting point and pressing the Shift-Down arrow key. To mark a column, place the cursor at the upper left corner of the block and press the Shift-Right arrow key until the highlight extends to the desired right edge. Then, press Shift-Down until the bottom of the block has been reached. Regardless of which marking mode is used, the block will be captured as soon as any non-marking key has been pressed. If either Del or Shift-Del is pressed, the block will first be captured and then deleted. To paste the block from the buffer into the text at the current cursor location, simply press Shift-Ins.

View file (f7). Any file may be viewed from within the shell. Press f7 and enter the name of the file to be viewed. The arrow keys and the Page Up or Page Down keys can be used to move about the file. Pressing esc returns you to the shell.

Print file (f8). Any file may be printed from within the shell if a printer is connected to the computer. Press f8 and enter the name of the file to be printed.

Copy file. Files may be copied from one location to another. The Copy File menu selection allows you to copy one or more files on a disk to another location. Two inputs are required: the file(s) to be copied (Copy From) and where the file(s) should be copied (Copy To). The source file specification may be a single file name or a set of files using the usual DOS conventions for wildcards (? to match a single character or * to match multiple characters). The destination specification should be a drive or a directory name (not the full file name).

For example, selecting *.* for "Copy From" and A: for "Copy To" will copy all files in the current directory (the HAZARD I data subdirectory) to drive A:

Shell to DOS (f5). Exit temporarily to DOS. The user may enter any DOS commands. When ready to return to HAZARD I, simply type

        EXIT

and enter at the DOS prompt.

Exit (f10). Selecting Exit returns the user to DOS, ending the session using the HAZARD I suite of programs.

```
 ┌──────────────────────────────────────────────────────────────────────┐
 │                                                                        │
 │   File   Create Input Data   Run Fire Model   Analyze Results    Help  │
 │                                                                        │
 │             ┌──────────────────── Setup ───────────────────────┐       │
 │             │        (Δ) Change Working Directory              │       │
 │             │        ( ) Setup FAST_in                         │       │
 │             │        ( ) Special Program Options               │       │
 │             │                                                  │       │
 │      ┌──────────────────────────────────────────────┐          │       │
 │      │C:\HAZARDI\DATA                                │          │       │
 │      └──────────────────────────────────────────────┘          │       │
 │      Data Subdirectory Name                                     │       │
 │                                                                 │       │
 │      ┌──────────────────────────────────────────────┐          │       │
 │      │                                               │          │       │
 │      └──────────────────────────────────────────────┘          │       │
 │      Special Program Options                                    │       │
 │       ├──────────────────────────────────────────────────────┤ │       │
 │           < OK >             < Cancel >          < Help >       │       │
 │                                                                        │
 │                                                                        │
 └──────────────────────────────────────────────────────────────────────┘
```

Setup. The Setup menu selection is used to change the default options for HAZARD I. You may change, create, or delete data subdirectories, modify the settings for colors, units, and default data files for the FAST_in module, or define special program options for the individual modules of HAZARDI. To change, create, or delete a data subdirectory, select the Change Working Subdirectory option, enter the name of the directory (your current data subdirectory is shown as a default), and select the operation desired (make current, create, or delete). To modify the FAST_in setting, just select the Setup FAST_in option. In either case, complete the operation by selecting < OK > or pressing enter. The setup dialog box is shown below.

```
 File    Create Input Data    Run Fire Model    Analyze Results         Help
         ┌─────────────────────────────────┐
         │ Interactive Data Input (FAST_in) │
         │ Multiple Fuel Packages (MLTFUEL)  │
         │ Examine Database (FIREDATA)       │
         │ Detector Activation (DETACT)      │
         └─────────────────────────────────┘



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```

In the second pulldown menu, **Create Input Data,** the modules which are used to create input data for the models of HAZARD I are shown. The arrow keys or the mouse may be used to select the individual module to be executed.

```
 File   Create Input Data   Run Fire Model   Analyze Results        Help
                           ┌─────────────────────────────┐
                           │ Input File: DATA.DAT         │
                           │ Output to: DATA.FST          │
                           │ Begin Simulation (FAST)      │
                           └─────────────────────────────┘



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```

The third pulldown menu, **Run Fire Model**, is used to execute the FAST model. The three selections on this pulldown menu allow you to select an input file to be run by FAST, specify the destination for any printed output from the FAST model, and begin model execution.

```
    File   Create Input Data   Run Fire Model   Analyze Results        Help

                  ─────── Select a File ───────
    File Spec   │*.DAT

        ASTMF02.DAT   DEMO-F3.DAT   NIKEA.DAT    SCEN-2M.DAT
        BASE.DAT      DEMO-F4.DAT   NOTEXT.DAT   SCEN-3.DAT
        CVENT.DAT     DEMOF1.DAT    RANCH.DAT    SCEN-4.DAT
        DATA.DAT      FLASH.DAT     RANCH1.DAT   SCEN-5.DAT
        DEMO-F1.DAT   IGNITE.DAT    SCEN-1.DAT   SCEN-6.DAT
        DEMO-F2.DAT   MDOT.DAT      SCEN-2.DAT   SCEN-7.DAT

          < OK >              < Cancel >            < Help >
```

When **Input file** is selected, the user is presented with a pop-up menu of all of the input files for the FAST model (those with the default extension of DAT). For FAST input and output files, you are presented with a list of files from which you may select any desired file. The dialog box for this entry is flexible to allow you to view any list of desired files. When you select input or output file, you can enter the desired filename is two ways. 1) Just enter the name of the file to be selected in the upper box of the dialog and press enter. 2) Use the standard DOS wildcards to display a list of files in the lower box of the dialog, press Tab to move to the list of files, and select the desired file. You can move back and forth between the file specification box and the list of files with the Tab or Shift-Tab keys until you find the file you want.

NOTE: Any valid existing DOS file may be selected. It is up to the user to insure the file selected is in the proper format to be used as an input file for the FAST model. Use of the default extensions suggested above will minimize potential problems in file selection.

Once a valid filename has been entered, the name of the file will appear in the menu list. In addition, the name of the **Output to** menu selection will be changed to the name of the input file with the default extension FST.

```
 File   Create Input Data   Run Fire Model   Analyze Results        Help


            ┌──────────────── Select a File ──────────────────┐
            │                                                  │
            │  File Spec  ┌─────────────────────────────────┐ │
            │             │*.FST                            │ │
            │             └─────────────────────────────────┘ │
            │                                                  │
            │   ┌────────────────────────────────────────────┐│
            │   │ Screen                                      ││
            │   │ PRN                                         ││
            │   │ LPT1                                        ││
            │   │ LPT2                                        ││
            │   │ LPT3                                        ││
            │   │ NUL                                         ││
            │   │ ■▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓┘ ││
            │                                                  │
            │  ┌─────────────────────────────────────────────┐│
            │  │  < OK >            < Cancel >      < Help >  ││
            │  └─────────────────────────────────────────────┘│
            │                                                  │
            └──────────────────────────────────────────────────┘
```
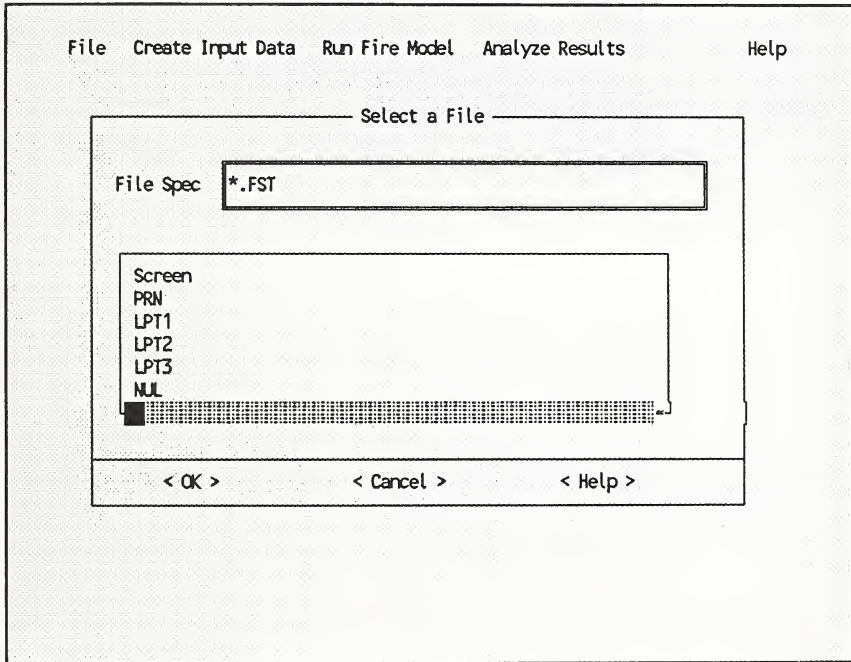
Usually, the printed output from the FAST model will be placed in a disk file with the same name as the input file but with the default extension of FST. The **Output to** menu selection allows the user to specify a different location for the output. Since the **Input file** menu selection changes the **Output to** destination,

Output to should be selected after the input file has been specified. Once again, the user is presented with a dialog box of possibilities for the output. At this point, the user may highlight one of the devices in the list select the file with the enter key or the left mouse button. Alternatively, the name of any DOS file may be entered by typing in the name of the file in the file specification text box. IF **Screen** is specified, the user should insure that the FAST input file does not contain any graphics specifications or the text will overwrite the graphics and unpredictable output will result. IF a printer device is selected (such as PRN, LPT1, or LPT2), the user MUST insure the printer is online and working as HAZARD I does not check and an attempt to print to a nonexisting or offline printer will lock up the machine. If NUL is selected, no output will be generated. If a file name is entered from the keyboard, care should be exercised to avoid overwriting an existing file with the output from the FAST model. Use of the default extensions suggested above will minimize potential problems in file selection.

```
   File    Create Input Data    Run Fire Model    Analyze Results         Help

                                                 ┌──────────────────────────┐
                                                 │ Examine Data (FASTplot)  │
                                                 │ Evacuation Model (EXITT) │
                                                 │ Tenability Limits (TENAB)│
                                                 ├──────────────────────────┤
                                                 │ Create Output File       │
                                                 └──────────────────────────┘


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```
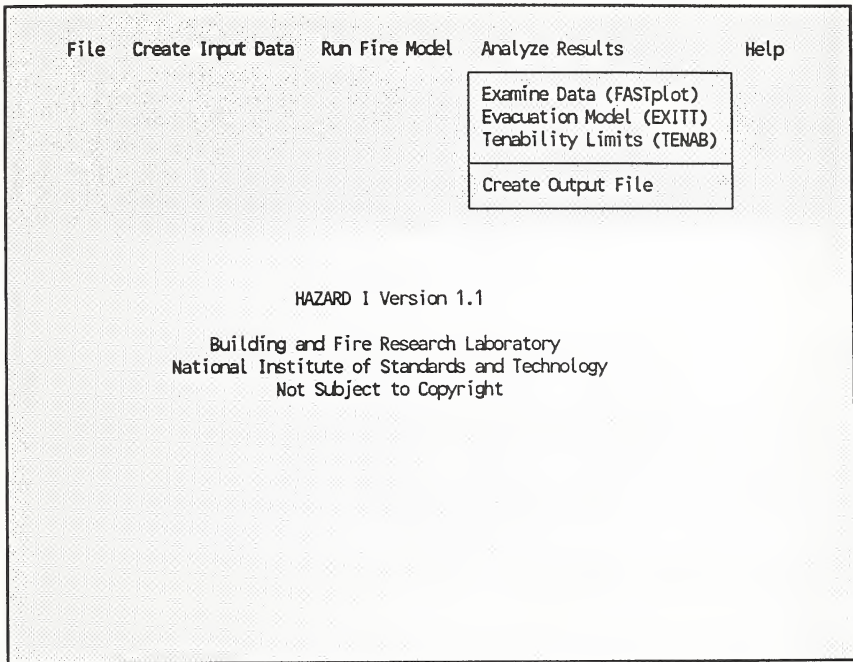
To analyze the results of a model run, press the right arrow key to present the
Analyze Results pulldown menu. This menu allows you to access the egress
and tenability modules, or to display the results graphically. In addition, you
can "recreate" a text output of a model from from a specially formatted disk file
created by the model.

```
   File   Create Input Data   Run Fire Model   Analyze Results        Help

   ┌──────────────────── Create Output File ────────────────────┐

   File Spec  │*.DMP                                          │

   Output File│                                               │

   ┌─────────────────────────────────┐  ┌──────────────────────┐
   │ CVENT.DMP      SCEN-2.DMP        │  │ [X] Initial Conditions│
   │ HCL.DMP        SCEN-3.DMP        │  │ [X] Normal Output     │
   │ HVAC.DMP       SCEN-4.DMP        │  │ [ ] Flow Field        │
   │ LOBA.DMP       SCEN-6.DMP        │  │ [ ] Species           │
   │ MANYVENT.DMP   SCEN-7.DMP        │  │ [ ] HAZARD 1 FED      │
   │ SCEN-1.DMP     SCEN-8.DMP        │  │ [ ] Purser FED        │
   └─────────────────────────────────┘  └──────────────────────┘

        < OK >            < Cancel >           < Help >
```

The create output file menu selection allows the user to create a text file from a FAST dump file (see section 4.4). Specify an input and output file and the desired content of the file. Selecting Initial Conditions and Normal Output produces the same output normally generated by FAST. Flow Field includes the flow through all vents in the simulation. Species includes the concentration of all species tracked in the simulation. HAZARD 1 FED and Purser FED includes a subset of the tenability information produced by the TENAB module of HAZARD I for all of the room in the simulation.

```
┌─────────────────────────────────────────────────────────────────────┐
│                                                                       │
│  File   Create Input Data   Run Fire Model   Analyze Results    Help  │
│                                                                       │
│            ┌───────────────── Help on Help ─────────────────┐         │
│          ┌─┴───────────────────────────────────────────────┬─┐       │
│          │ Help is available by pressing the Help key (f1) or by selecting │≡│
│          │ the Help pulldown menu with the mouse or by pressing Alt-H.    │█│
│          │ When the help screen is visible, you may view the selected help │ │
│          │ text by scrolling up and down the help text with the arrow keys │ │
│          │ or the mouse.  In addition, you may view this help message by   │ │
│          │ selecting Help on Help, view any of the available help messages │ │
│          │ by selecting Keyword Help, or return to the program by          │ │
│          │ selecting OK.  You can move between objects on the help screen  │ │
│          │ with the Tab or the Shift-Tab key.                              │ │
│          │                                                                 │Y│
│          └─────────────────────────────────────────────────────────────┴─┘
│          │     < OK >            < Help on Help >      < Keyword Help >    │
│          └─────────────────────────────────────────────────────────────┘  │
│                                                                            │
│                                                                            │
│                                                                            │
└────────────────────────────────────────────────────────────────────────────┘
```

To access help which describes the function of each of the HAZARD I modules, press enter. A help screen is displayed describing the online help system. Press esc to remove the help text and continue. You may also choose Index to select among a complete list of all the help topics available.

4.2 DETACT

DETACT is a program to predict the response of thermal detectors to fires of arbitrary heat release rate. Although primarily designed to predict sprinkler response, it can also be used to determine activation time of smoke detectors. Note that EXITT will also calculate the alarm time of smoke detectors. DETACT uses a temperature rise criteria to determine alarm time while EXITT uses a predetermined smoke layer thickness in the room.

To use DETACT, select it from the shell or type

    DETACT

and press enter at the DOS prompt. It is an interactive program where the user answers questions to input the data, and the results are presented in tabular form. Any user familiar with the calculation procedure described in Appendix C of ANSI/NFPA 72E should have no problem with this program as the procedures are similar. The questions asked are as follows:

1. HEIGHT OF CEILING ABOVE FUEL (METERS) - This is not the floor to ceiling height, but rather the distance from the top surface of the burning object to the ceiling.

2. DISTANCE OF DETECTOR FROM AXIS OF FIRE (ME-TERS) - This is the radial distance to the detector from a point directly above the fire.

3. INITIAL ROOM TEMPERATURE (CELSIUS) - The room ambient temperature.

4. DETECTOR ACTIVATION TEMPERATURE (CELSIUS) - The temperature rating of the device. The activating of a smoke detector can be estimated by using an activation temperature of 13 °C above the initial room temperature value entered above.

5. DETECTOR RESPONSE TIME INDEX (RTI) - For sprinklers, this is now often given in the manufacturer's catalog. For fixed-temperature heat detectors, table 4-1 gives RTI values corresponding to UL spacings. For rate-of-rise detectors, table 4-2 gives RTI values for three rate-of-rise settings (NOTE: 15 °F/min is typical for U.S. commercial devices).

6. RATE OF HEAT RELEASE - The rate of heat release of the fire (which can be obtained from the FAST run with FASTplot by LISTing the variable HEAT) is entered one point at a time by answering the questions TIME (SEC) and HEAT RELEASE RATE (kw) starting with time=0. When the last desired point is entered, the user enters a -1 value for time, which stops the request for data. The results are then sent to the printer (or the screen if the user answers the question SEND OUTPUT TO PRINTER? with a N) in tabular form.

Table 5. RTI values for fixed-temperature heat detectors

UL Listed Spacing	UL Listed Activation Temperature						All FM Listed Temps.
(ft/m)	128°F (53°C)	135°F (57°C)	145°F (63°C)	160°F (71°C)	170°F (77°C)	196°F (91°C)	
10/3.1	894/494	738/408	586/324	436/241	358/198	217/120	436/241
15/4.6	559/309	425/235	349/193	246/136	199/110	101/56	246/136
20/6.1	369204	302/167	235/130	157/87	116/64	38/21	157/87
25/7.6	277/153	224/124	174/96	107/59	72/40	---	107/59
30/9.2	212/117	179/99	136/75	81/45	49/27	---	81/45
40/12.2	159/88	128/71	92/51	40/22	---	---	---
50/15.3	132/73	98/54	67/37	---	---	---	---
70/21.4	81/45	54/30	20/11	---	---	---	---

NOTE: These RTI's are based on an analysis of the Underwriters Laboratories (UL) and Factory Mutual (FM) listing test procedures. Plunge test results on the detector to be used will give a more accurate response time index.

RTIs are shown in (ft•s)$^{1/2}$/(m•s)$^{1/2}$. Since the original work was in english units, the SI units are approximate.

Table 6. RTI values for rate-of-rise heat detectors

Listed Spacing	UL Listed Activation Rate of Temp. Rise		
(ft/m)	15°F/min 8°C/min	20°F/min 11°C/min	25°F/min 14°C/min
10/3.1	1834/1013	1308/722	984/543
12.5/3.8	1453/802	1073/593	805/445
15/4.6	1185/654	872/482	637/352
20/6.1	872/482	581/321	425/235
30/9.2	559/309	380/210	280/155
40/12.2	447/247	291/161	206/114
50/15.3	425/235	246/136	161/89

RTIs are shown in $(ft{\bullet}s)^{1/2}/(m{\bullet}s)^{1/2}$. Since the original work was in english units, the SI units are approximate.

4.3 EXITT

EXITT (version 18) is a deterministic model for simulating how people egress a building in which there is a fire. EXITT (version 18) is written in FORTRAN and is a translation of the EXITT BASIC version. It is designed to be used with a dump file from a run of FAST and provide an input file for TENAB (version 18). EXITT requires 2 input files and produces 2 output files.

To use EXITT, select it from the shell or type

        EXITT

and press enter at the DOS prompt. To run the model, the user types appropriate file names as prompted. The user will be prompted for the names of the FAST dump file, a building-occupant set file, a user's output file, and an EXITT dump file.

4.3.1 Input from FAST

The first prompt will be for the name of the FAST dump file to be used. The user may select a test case dump file or any FAST dump file he has created. In the event that the file does not exist or the name is invalid, the user will be informed and asked to reenter the dump file name. After entering a valid file name, the user will again be prompted for a FAST dump file. If additional FAST dump files are to be used (if the FAST restart facility is used to generate multiple dump files as explained in the section on FAST in this chapter) the user enters them one at a time. When there are no more FAST dump file names to enter, the user should press the return key. If the user desires to cancel the run when prompted for a file name, a / may be entered. In the case a file specified for the FAST dump file is not a FAST dump file, the error will only be realized when the program attempts to read the file. When a FAST dump file is recognized as "bad," the user will be informed that the file is not a FAST dump file and the run will be stopped.

4.3.2 Input from a Building-Occupant File

The second prompt will be for the name of the file describing the building and its occupants. Examples of building-occupant files are included for each example case included on the HAZARD I disks. As above, the user may enter the name of a test case building-occupant file or that of a building-occupant file created by the user. If the file does not exist or the name is invalid, the user will be informed and asked to reenter the file name. If the user wishes to cancel the run at this time he may enter a /.

4.3.3 Format for a Building-Occupant File

Using a text editor the user may create his own building-occupant file. The building file contains nine sections, each beginning with a specific keyword. A sample building file is shown on the next page. It should be noted that all of the input in a building file is in "free format." That is, the placement of the input numbers in a particular format on a line or on a particular line is arbitrary as is used in the examples below for clarity. Actually, if a particular input requires 10 numbers, the next 10 numbers in the input file will be used. In practice, this makes for easier input without the worry of placing inputs in a particular column of an input line. However, note that a missing input number on one line may lead to errors on all the following inputs.

ROOMS. The first section consists of the keyword ROOMS followed by a line containing two integers. The first integer indicates the number of rooms associated with the FAST dump file (which will be between 1 and 6) and the second integer represents the number of nodes (a node is a room, a location within a room, a door or a window) in the EXITT floor plan. The maximum number of nodes allowed is 100. In the sample building file the first section is the line

ROOMS 6 15

indicating the associated FAST dump file was run with 6 rooms and that EXITT is run with 15 nodes.

```
ROOMS 6 15
NODESTOFAST 1 2 3 4 5 6 8 7 4 3 2 2 2 2 2
NODESTOEXITT 1 2 3 4 5 6 4 4 4 3 2 2 2 2 2
NODEHGT 2.4 2.3 2.3 2.3 2.3 2.3 2.3 2.3 2.1 2.3 2.3 2.3 2.3 2.3 2.3
FLRHGT 0. 0. 0. 0. 0. 0. 0. 0. .2 0. 0. 0. 0. 0. 0.
AMBNOISE 35 35 35 35 35 35 35 35 35 35 35 35 35 35 35
DETECTORS 1
-1.
2
83 95 83 83 83 83 83 83 83 83 83 83 83 83 83
NODETONODE 22
1 11 2.3
2 11 4.81    2 12 1.0    2 13 4.81    2 14 4.7    2 15 4.7
3 7 4.95     3 10 4.95
4 8 4.95     4 9 4.95
5 12 2.3
6 13 2.3
9 13 4.81    9 15 4.7
10 11 4.81   10 14 4.7
11 12 4.7    11 14 1.0
12 13 4.7    12 14 4.81   12 15 4.81
13 15 1.0
OCCUPANTS 4
1 7 33 30
0 1 1 0
0 0 1 1
5 6 1 1
1 0 0 0
0. 8. 0. 0.
-1. -1. -1. -1.
```

NODESTOFAST. The second section contains the mapping between the EXITT nodes and the FAST dump file room numbers. If there are NRM rooms in FAST, then "FAST" room number $NRM + 1$ corresponds to a door of EXITT (outside) and $NRM + 2$ corresponds to a window of EXITT. If there are N nodes for EXITT, then this section consists of the keyword NODESTOFAST followed by a line of N "FAST" room numbers with the first entry corresponding to node 1 of EXITT, the second entry corresponding to node 2 of EXITT, etc. The second section of the sample building file appears below.

NODESTOFAST 1 2 3 4 5 6 8 7 4 3 2 2 2 2 2

The third section contains a mapping between the EXITT nodes and the EXITT room numbers. In order to "cluster" nodes together into rooms, a mapping between EXITT nodes and EXITT room numbers is needed. If there are N nodes for EXITT, then this section consists of the keyword NODESTOEXITT followed by a line of N "EXITT" room numbers with the first entry corresponding to node 1 of EXITT, the second entry corresponding to node 2 of EXITT, etc. The EXITT room numbers may not be the same as a window or door node number and window and door nodes should be assigned to the EXITT room in which they are located.

NODESTOEXITT 1 2 3 4 5 6 4 4 4 3 2 2 2 2 2

For the sample building file the mapping between EXITT nodes and FAST rooms is that Node 1 is in room 1 of FAST, Node 2 is in room 2 of FAST, Node 3 is in room 3 of FAST, Node 4 is in room 4 of FAST, Node 5 is in room 5 of FAST, Node 6 is in room 6 of FAST, Node 7 is a window corresponding to the room of FAST in which it is located (Room 8 of FAST indicates to TENAB a window situation), Node 8 is a door corresponding to the outside for FAST (Room 7 of FAST is considered the outside to TENAB), Node 9 is in room 4 of FAST, Node 10 is in room 3 of FAST, Node 11 is in room 2 of FAST, Node 12 is in room 2 of FAST, Node 13 is in room 2 of FAST, Node 14 is in room 2 of FAST, and Node 15 is in room 2 of FAST. The mapping between EXITT nodes and EXITT rooms is as follows: node 1 is room 1, nodes 2, 11, 12, 13, 14, and 15 are in room 2, nodes 3 and 10 are in room 3, nodes 4, 7, 8, and 9 are in room 4, node 5 is in room 5, and node 6 is in room 6. In this particular case the window (node 7) and the door (node 8) are both in room 4.

NODEHGT. The fourth section consists of the keyword NODEHGT followed by a line of N non-negative floating point numbers representing the node height. The node height is the distance between the floor level and the ceiling (meters)

at the node. The lines corresponding to this section of the sample building file are shown below.

NODEHGT 2.4 2.3 2.3 2.3 2.3 2.3 2.3 2.3 2.1 2.3 2.3 2.3 2.3 2.3 2.3

The first node has an associated room height of 2.4 m and nodes 2-8 and 10-15 have an associated room height of 2.3 m and node 9 has an associated height of 2.1 m.

FLRHGT. Since the FAST model is limited to a total of six rooms, several rooms of an actual building may have to be combined for the model run. If the combined rooms have different floor heights, EXITT must have that information to accurately determine the exposure conditions at each node within the building (for example, a room with a balcony where a node is "in" the balcony 2.4 m above the floor of the room containing the balcony). The fifth section consists of the keyword FLRHGT followed by a line of N non-negative floating point numbers representing the floor height of the node (in m) above the floor of the room. The fifth section of the sample building file is shown below.

0. 0. 0. 0. 0. 0. 0. 0. .2 0. 0. 0. 0. 0. 0.

The fifth section of the sample building file indicates that nodes 1-8 and 10-15 have an associated floor elevation of 0. m and Node 9 has an associated floor elevation of 0.2 m.

AMBNOISE. The sixth section is the keyword AMBNOISE followed by a line of NN (the total number of nodes used by EXITT) integers representing the base noise level in decibels associated with each EXITT node. The section of the sample building file corresponding to the fifth section is shown below.

AMBNOISE 35 35 35 35 35 35 35 35 35 35 35 35 35 35 35

This section indicates the noise level of each room of the building is 35 decibels.

DETECTORS. The seventh section gives the smoke detector information. The first number of this section indicates the number of smoke detectors in the building, NSD (a maximum of 10 is allowed). If there is at least one smoke detector, a second, third and fourth line for this section are required. The second line consists of NSD real numbers indicating the time each alarm will sound. If an entry is non-negative the alarm will sound at that number of seconds; if an entry is negative, then the EXITT program will determine when that particular alarm will sound. The third line consists of NSD integers representing the node location associated with each detector, the first entry being associated with the location of the first detector, the second entry being associated with the location of the second detector, etc. The fourth line consists of NSD rows, one row per detector. Each row contains NN integers representing the loudness of the detector in decibels at each EXITT node when the detector is sounding. A rule of thumb for determining these levels is that for the node at which the detector is sounding the level is 95 decibels, 12 decibels are lost for nodes farther away from the detector, 12 decibels are lost in "going" through a closed door and 12 decibels are lost for a node on a different floor from that of the sounding detector's floor. The seventh section for the sample building file appears below.

DETECTORS 1
-1.
2
83 95 83 83 83 83 83 83 83 83 83 83 83 83 83

The first line of this section indicates that there is one smoke detector. The second line, -1., indicates that the time that the alarm begins sounding will be determined by the EXITT program. The third line indicates that the smoke detector is located at node 2 and the fourth section indicates that the loudness of the alarm in rooms 1 and 3-6 will be 83 decibels and that in room 2 the loudness of the alarm will be 95 decibels.

NODETONODE. The eighth section consists of the distances between adjacent nodes (two nodes are adjacent if one can travel from one node to the other without going through any other nodes). The first line of this section contains

the keyword NODETONODE followed by an integer indicating the number of edges (an edge being the path between adjacent nodes) entered, NEDGES. The second through NEDGES+1-st entries each contain 2 integers and a non-negative floating point number. The first integer represents the "from" node, the second integer represents the "to" node and the floating point number represents the distance in meters between the two nodes. If the distance between nodes x and y is d, the distance between y and x is assumed to be d unless the file specifies that the distance between y and x is otherwise. This may occur, for example, in the case of stairwell, where going up the stairs from node x to y takes longer than going down the stairs from node y to x. The eighth section of the sample building file is below.

```
NODETONODE 22
1 11 2.3
2 11 4.81    2 12 1.0    2 13 4.81    2 14 4.7    2 15 4.7
3 7 4.95     3 10 4.95
4 8 4.95     4 9 4.95
5 12 2.3
6 13 2.3
9 13 4.81    9 15 4.7
10 11 4.81   10 14 4.7
11 12 4.7    11 14 1.0
12 13 4.7    12 14 4.81   12 15 4.81
13 15 1.0
```

The first line of this section indicates that there are 22 edges. The next 22 entries list the pairs of adjacent nodes and their corresponding distances. The first edge, given by 1 11 2.31, indicates that the distance between nodes 1 and 11 is 2.31 m. The second edge, 2 11 4.81, indicates the distance between nodes 2 and 11 is 4.81 m. The remaining edges are interpreted in a similar manner.

OCCUPANTS. The ninth section of the file, shown below, describes the occupants of the building.

OCCUPANTS 4

```
1 7 33 30
0 1 1 0
0 0 1 1
5 6 1 1
1 0 0 0
0. 8. 0. 0.
-1. -1. -1. -1.
```

The first line of this section is an integer between 1 and 10 indicating the number of people in the building. The second line is a list of the ages of the occupants of the building. The third line is a list of 1's and 0's indicating the sex of the occupants (male=1 and female=0). The fourth line is a list of 1's and 0's indicating which occupants are awake and which are asleep (awake=1 and asleep=0). The fifth line is a list of nodes which indicate the locations of the occupants at the beginning of the simulation time. The sixth line is a list of 1's and 0's indicating which occupants require help in egressing the building (help required=1 and no help required=0). The seventh line is a list of sleeping penalties for the occupants. For occupants who are not asleep, the penalty is 0. For occupants who have difficulty waking, such as occupants who have hearing loss and young children, the penalty assigned is between 0 and 50. decibels. For occupants who wake easily, such as mothers of infants, the sleeping penalty assigned is between -15 and 0 decibels. The last line indicates the travel speed of each occupant. A non-positive number indicates that the default speed of 1.3 m/s is to be used. A positive number is interpreted as being the travel speed of the occupant in m/s.

If line 1 indicates there are N occupants, then each of lines 2 through 7 must have N entries with the first entry being associated with occupant 1, the second entry being associated with occupant 2, etc. It is noted here that if an occupant is 3 years of age or less, he will be considered to require help in egressing the building regardless of what the occupant set file indicates.

In this case there are four people, ages 1, 7, 33, and 30. The 1-year old is a sleeping female at node 5 who requires help in order to leave the building. The 7-year old is a deep sleeper (sleeping penalty of 8 decibels) at node 6 who is

capable of leaving the building on his own. The third person is an awake 33-year-old capable male located at node 1, and the fourth person is an awake 30-year-old capable female also located at node 1. In this case the default travel speed is assumed for each occupant.

4.3.4 User's Output from EXITT

The fourth prompt will be for the name of the user's output file. This file stores the names of files used in making the run, the building-occupant set data and the actions of the occupants as they egress the building. The file name can be a disk file name, the screen (CON on the PC), the printer (PRN on the PC) or the null file (NUL on the PC - use when the output file is not desired). If the file already exists, the user will be informed and allowed the opportunity to overwrite the file if desired. If the file name is invalid, the user will be informed and asked to reenter the file name. If the user wishes to cancel the run at this time a / may be entered. A sample output file appears below.

```
EXITT Version:  18.0 - Creation Date: 12/05/88 - Run Date: 12/08/88
FAST DUMP FILE   :  \EXITT2\SCEN-5.DMP
BUILDING FILE    :  SCEN-5.BLD
EXITT OUTPUT FILE:  SCEN-5.OUT
EXITT DUMP FILE  :  NUL


NO. OF ROOMS (RUN WITH FAST)        6
NO. OF DOORS                        3
NO. OF WINDOWS                      3
TOTAL NUMBER OF NODES              25
```

EXITT NODE NUMBER	EXITT ROOM NUMBER	FAST ROOM NUMBER	ROOM HEIGHT (M)	FLOOR HEIGHT (M)
1	1	1	2.4	0.0
2	2	1	2.4	0.0
3	3	2	2.4	0.0
4	3	4	4.9	0.0
5	5	5	2.4	0.0
6	6	6	2.4	0.0
7	7	6	2.4	0.0
8	8	5	2.4	0.0
9	9	3	2.4	0.0

10	10	5	2.4	0.0
11	3	7	2.4	0.0
12	2	7	2.4	0.0
13	1	7	2.4	0.0
14	6	8	2.4	0.0
15	7	8	2.4	0.0
16	8	8	2.4	0.0
17	5	5	2.4	0.0
18	3	2	2.4	0.0
19	1	1	2.4	0.0
20	3	2	2.4	0.0
21	2	1	2.4	0.0
22	5	4	2.4	2.5
23	2	1	2.4	0.0
24	8	5	2.4	0.0
25	8	5	2.4	0.0

NODE NUMBER	NOISE LEVEL (DECIBELS)
1	35
2	35
3	35
4	35
5	35
6	35
7	35
8	35
9	35
10	35
11	35
12	35
13	35
14	35
15	35
16	35
17	35
18	35
19	35
20	35
21	35
22	35
23	35
24	35
25	35

NUMBER OF SMOKE DETECTORS: 2

SMOKE DET NO.   NODE   ACTIVATION TIME (SEC)

```
        1               3        TO BE DETERMINED BY EXITT
        2               5        TO BE DETERMINED BY EXITT
```

EXITT NODE NUMBER	ALARM LEVEL (DECIBELS)	
	1	2
1	83	71
2	83	71
3	95	71
4	83	71
5	71	95
6	59	71
7	59	71
8	59	71
9	83	71
10	59	71
11	83	71
12	83	71
13	83	71
14	59	71
15	59	71
16	59	71
17	71	95
18	95	71
19	83	71
20	95	71
21	83	71
22	71	71
23	83	71
24	59	71
25	59	71

EDGE LIST

FROM NODE	TO NODE	DISTANCE (M)
1 -	13	2.81
-	18	2.59
-	19	2.50
2 -	19	2.13
-	21	2.61
-	23	2.93
3 -	4	2.20
-	18	2.29
-	20	2.18
4 -	3	2.20
-	20	1.71
-	22	4.56
5 -	17	1.83
-	22	1.74
-	25	1.61
6 -	14	1.37

-	17	2.07
7 -	15	1.37
-	17	3.29
8 -	16	1.95
-	24	2.33
-	25	1.90
9 -	18	1.07
10 -	24	1.22
11 -	20	1.02
12 -	21	1.70
13 -	1	2.81
-	19	3.36
14 -	6	1.37
15 -	7	1.37
16 -	8	1.95
-	24	2.85
17 -	5	1.83
-	6	2.07
-	7	3.29
-	22	1.57
18 -	1	2.59
-	3	2.29
-	9	1.07
19 -	1	2.50
-	2	2.13
-	13	3.36
20 -	3	2.18
-	4	1.71
-	11	1.02
-	23	1.45
21 -	2	2.61
-	12	1.70
-	23	1.07
22 -	4	4.56
-	5	1.74
-	17	1.57
23 -	2	2.93
-	20	1.45
-	21	1.07
24 -	8	2.33
-	10	1.22
-	16	2.85
-	25	3.14
25 -	5	1.61
-	8	1.90
-	24	3.14

TOTAL NUMBER OF DIRECTED EDGES   62

NUMBER OF PEOPLE   4

PERSON	LOCATION	AGE	SEX	STATE	SLEEP PENALTY	REQUIRE ASSISTANCE	TRAVEL SPEED
1	8	25	MALE	ASLEEP	0.0	NO	1.30
2	8	23	FEMALE	ASLEEP	0.0	NO	1.30
3	7	2	MALE	ASLEEP	0.0	YES	1.30
4	6	0	MALE	ASLEEP	0.0	YES	1.30

ACTIONS TAKEN BY PERSON   1

NODE	ROOM	TIME	SAV-ING	SAVED BY	DESTI-NATION	ACTION
8	5	0.0	--	--	--	INITIAL POSITION
8	5	364.0	4	--	6	GO TO RESCUE OTHER
25	5	366.4	4	--	6	ARRIVE AT NEW NODE
5	5	368.5	4	--	6	ARRIVE AT NEW NODE
17	5	370.9	4	--	6	ARRIVE AT NEW NODE
6	6	372.1	4	--	6	ARRIVE AT NEW NODE
6	6	372.1	4	--	--	PREPARE ANOTHER TO LEAVE BUILDING
6	6	374.1	4	--	--	ASSIST ANOTHER OUT OF BUILDING
14	8	374.9	4	--	14	ARRIVE AT WINDOW

ACTIONS TAKEN BY PERSON   2

NODE	ROOM	TIME	SAV-ING	SAVED BY	DESTI-NATION	ACTION
8	5	0.0	--	--	--	INITIAL POSITION
8	5	364.0	3	--	7	GO TO RESCUE OTHER
25	5	366.4	3	--	7	ARRIVE AT NEW NODE
5	5	368.5	3	--	7	ARRIVE AT NEW NODE
17	5	370.9	3	--	7	ARRIVE AT NEW NODE
7	6	372.8	3	--	7	ARRIVE AT NEW NODE
7	6	372.8	3	--	--	PREPARE ANOTHER TO LEAVE BUILDING
7	6	375.8	3	--	--	ASSIST ANOTHER OUT OF BUILDING
15	8	376.6	3	--	15	ARRIVE AT WINDOW

ACTIONS TAKEN BY PERSON   3

NODE	ROOM	TIME	SAV-ING	SAVED BY	DESTI-NATION	ACTION
7	6	0.0	--	--	--	INITIAL POSITION
7	6	372.8	--	2	--	RECEIVING ASSISTANCE
7	6	375.8	--	2	--	LEAVE BUILDING WITH ASSISTANCE
15	8	376.6	--	2	15	ARRIVE AT WINDOW WITH ASSISTANCE

ACTIONS TAKEN BY PERSON   4

NODE	ROOM	TIME	SAV-ING	SAVED BY	DESTI-NATION	ACTION
6	6	0.0	--	--	--	INITIAL POSITION

```
 6   6 372.1   --   1   --  RECEIVING ASSISTANCE
 6   6 374.1   --   1   --  LEAVE BUILDING WITH ASSISTANCE
14   8 374.9   --   1   14  ARRIVE AT WINDOW WITH ASSISTANCE
```

The output from EXITT is divided into a number of sections. The first several sections simply reproduce the data from the building file developed by the user. The remaining sections show the results of the calculation, grouped to show all of the actions for each occupant of the building. Each line of the output shows the location (*NODE* and *ROOM* number), *TIME*, who was being assisted by the occupant (*SAVING*), who was assisting the occupant (*SAVED BY*), where the occupant decided to go (a *DESTINATION* node number), and the *ACTION* the occupant decided upon. Note that at this point, we simply know the path each occupant would take during an escape. The effects of the fire on the occupants (i.e., their ability to escape the fire without becoming incapacitated or dying) are determined by TENAB.

4.3.5 The EXITT Dump File

The last prompt will be for the name of the EXITT dump file. This file is designed for use as input to the TENAB program. The file name can be a disk file name or the null file (NUL on the PC - use when the output file is not desired). If the file does not exist, the user will be informed and allowed the opportunity to overwrite the file, provided the name entered is not the same as that entered for the user's output file. If the file name is invalid, the user will be informed and asked to reenter the file name. If the user wishes to cancel the run at this time, a / may be entered.

Once all the file names are entered, the user just awaits the run to finish. Any file errors (for example, a negative age) encountered which cause the program to stop are printed on the screen.

4.4 FAST

The computer model requires a description of the problem to be solved. The following description is for the input data used by the model. In general, the order of the data is not important. The one exception to this is the first line which specifies the version number and gives the data file a title.

The data are grouped as

- Run initialization,
- Ambient conditions,
- Floor plan data,
- Connections,
- Thermophysical properties of the enclosing surfaces,
- Fire specifications,
- Species production,
- Files, and
- Graphics specification.

The number of lines in a given data set will vary depending for example on the number of openings or the number of species tracked. A number of parameters such as heat transfer and flow coefficients have been set within the program as constants. Please refer to the section on source terms to ascertain the values for these parameters.

Each line of the input data file begins with a key word which identifies the type of data on the line. The key words which are currently available are:

CEILI	specify name of ceiling descriptor(s)
CHEMI	miscellaneous parameters for kinetics
CO	CO/CO_2 mass ratio
CT	fraction of fuel which is toxic
CVENT	opening/closing parameter
DEPTH	depth of compartments
DUMPR	specify a file name for saving time histories

EAMB	external ambient
FAREA	area of the base of the fire
FHIGH	height of the base of the fire
FLOOR	specify the name of floor property descriptor(s)
FMASS	pyrolysis rate
FQDOT	heat release rate
FTIME	length of time intervals
HCL	hcl/pyrolysis mass ratio
HCN	hcn/pyrolysis mass ratio
HCR	hydrogen/carbon mass ratio of the fuel
HEIGH	interior height of a compartment
HI/F	absolute height of the floor of a compartment
HVENT	specify vent which connect compartments horizontally
INELV	specify interior node elevations of mechanical ventilation system nodes
INTER	initial height of the upper/lower interface
LFBO	compartment of fire origin
LFBT	type of fire
LFMAX	number of time intervals
LFPOS	position of the fire in the compartment
MVOPN	describe an opening between a compartment and the ventilation system
MVDUCT	describe a piece of (circular) duct work
MVFAN	give the pressure - flow relationship for a fan
O2	oxygen/carbon mass ratio of the fuel
OD	C/CO_2 mass ratio
RESTR	specify a restart file
TAMB	ambient inside the structure
TIMES	time step control of the output
VVENT	specify a vent which connects compartments vertically
VERSN	version number and title
WALLS	specify the name of wall property descriptor(s)
WIDTH	width of the compartments
WIND	scaling rule for wind effects

The number in parenthesis is the maximum number of entries for that line. "N" represents the number of compartments being modeled and "lfmax" is the number of time intervals used to describe the fire, detailed below in section 6.7. The outside (ambient) is designated by one more than the number of compartments, $N+1$. Thus, a three compartment model would refer to the outside as compartment four.

Each line of input consists of a label followed by one or more alphanumeric parameters associated with that input label. The label must always begin in the first space of the line and be in capital letters. Following the label, the values may start in any column and all values must be separated by either a comma or a space. Values may contain decimal points if needed or desired. They are not required. Units are standard SI units. Most parameters have default values which can be utilized by omitting the appropriate line. These will be indicated in the discussion. The maximum line length is 128 characters, so all data for each key word must fit in this number of characters. For each entry which requires more than one type of data, the first entry under the column "parameter" indicates the number of data required.

4.4.1 Run Initialization

The first line in the file <u>must</u> be the version identification. It is the line that FAST keys on to determine whether it has a correct data file. The format is fixed, that is the data must appear in the columns specified in the text.

Keyword:	VERSN
Inputs:	Version Number, Title

The VERSN line is a required input.

Version Number	The version number parameter specifies the version of FAST for which the input data file was prepared. Normally, this would be 18. It must be in columns 8-9.
Title	The title is optional and may consist of letters, numbers, and/or symbols that start in column 11 and may be up to 50 characters. It permits the user to uniquely label each run.

Example:

```
VERSN   18 Simulation for Building XYZ
```

Keyword:	TIMES
Inputs:	Simulation time, Print Interval, Dump Interval, Display Interval, Copy Count

The TIMES line is required data.

Simulation Time (s)	Simulation time is the length of time over which the simulation takes place. The maximum value for this input is 86400 s (1 day). The simulation time parameter is required.
Print Interval (s)	The print interval is the time interval between each printing of the output values. If omitted or less than or equal to zero, no printing of the output values will occur.
Dump Interval (s)	The dump interval is the time interval between each writing of the output to the dump file. The dump file stores all of the output of the model at the specified interval in a format which can be efficiently retrieved for use by other programs. Section 4.4.8 provides details of the dump file. A zero must be used if no dump file is to be used. There is a maximum of 50 intervals allowed. If the choice of this parameter would yield more than 50 writes, it is adjusted so that this limit is not exceeded.
Display Interval (s)	The display interval is the time interval between each graphical display of the output as specified in the graphics specification, section 6.10. If omitted, no graphical display will occur. There is a limit on the display of 50 for the microcomputer versions and 100 for the mainframe versions of FAST. This parameter is not adjusted; rather graphs will be truncated to the first 50 or 100 points, respectively.

Copy Count	Copy count is the number of copies of each graphical display to be made on the selected hard copy device as specified in the graphics specification, section 2.9. If omitted, a value of zero (no copies) is assumed.

Examples:

```
TIMES   360   0   0
TIMES   360  10  30
TIMES   900      30      10      10      0
```

In the first example, a simulation time of 360 s is specified. The output values will not be printed or stored in a dump file. No graphical display of the output will occur. In the second example, a 360 s simulation with printed output every 10 s and output to a dump file every 30 s is specified. No graphical display of the output values will be generated. In the third example, all parameters are specified. A 900 s simulation with printed output every 30 s, output to a dump file every 10 s and a graphical display with no copies will occur every 10 s. Note the free field format of these parameters - multiple spaces between parameters are permitted.

Keyword:	CNVG
Inputs:	Approximate Conduction, Convergence Factor, Pressure Damping
Diagnostic parameters	
Approximate Conduction	This is a logical switch. If set to zero, the usual heat transfer thru partitions is calculated. If set to any non zero value then the semi-infinite slab approximation is used. The default is 0.

Convergence Factor	Modifies the convergence criterion used by the solver for the relative error at each time step. The default is 1.0
Pressure Damping	Used to damp pressure fluctuations. The default is 0.

The diagnostic parameters must be used with extreme caution. These parameters can not be set in the data editor for the main model. While running computations within the data editor, the speed enhancement for the conduction can be utilized. Normally, a linear parabolic equation is solved for the heat transfer through each partition. The solution is *via* a successive over-relaxation technique. When the walls are thick, or the simulation time will be very short, it is reasonable to assume that the thermal wave will not reach the outside boundary. In this case, there is an analytic solution to the conduction equation which can be written in terms of the "error function," ERFC [13]. The other two parameters modify the convergence criteria used by the numerical solver. The default values are unity, and should normally be left at those values.

4.4.2 Ambient Conditions

The ambient conditions section of the input data allows the user to specify the temperature and pressure and station elevation of the ambient atmosphere, as well as the absolute wind pressure to which the structure is subjected. There is an ambient for the interior and for the exterior of the building. The key word for the interior of the building is TAMB and for the exterior of the building is EAMB. The form is the same for both. The key word for the wind information is WIND. The wind modification is applied only to the vents which lead to the exterior. Pressure interior to a structure is calculated simply as a lapse

rate based on the NOAA tables [17]. For the exterior, the nominal pressure is modified by

$$\delta(p) = C_w \rho V^2 \quad \text{where} \quad V = V_w \left(\frac{H_i}{H_w} \right)^{p_w} \tag{1}$$

This modification is applied to the vents which lead to the exterior ambient. The pressure change calculated above is modified by the wind coefficient for each vent. This coefficient, which can vary from -1.0 to +1.0, nominally from -0.8 to +0.8, determines whether the vent is facing away from or into the wind. The pressure change is multiplied by the vent wind coefficient and added to the external ambient for each vent which is connected to the outside.

Keywords:	EAMB and TAMB
Inputs:	Ambient Temperature, Ambient Pressure, Station Elevation
These data are optional.	

Ambient Temperature (K)	Ambient temperature is the temperature of the ambient atmosphere. Default is 300.
Ambient Pressure (Pa)	The ambient pressure is the pressure of the ambient atmosphere. Default is 101300.

Station Elevation (m)	The station elevation is the elevation of the point at which the ambient pressure and temperature (see above) are measured. The reference point for the elevation, pressure and temperature must be consistent. This is the reference datum for calculating the density of the atmosphere as well as the temperature and pressure inside and outside of the building as a function of height. Default is 0.

Keywords: WIND Inputs: Ambient Temperature, Ambient Pressure, Station Elevation This line is optional.	
Wind Speed (m/s)	Wind speed at the reference elevation. The default is 0.
Reference Height (m)	Height at which the reference wind speed is measured. The default is 10 m.
Lapse Rate Coefficient	The power law used to calculate the wind speed as a function of height. The default is 0.16.

The choice for the station elevation, temperature and pressure must be consistent. Outside of that limitation, the choice is arbitrary. It is often convenient to choose the base of a structure to be at zero height and then reference the height of the building with respect to that height. The temperature and pressure must then be measured at that position. Another possible choice would be the pressure and temperature at sea level, with the building elevations then given with respect to mean sea level. This is also acceptable, but somewhat more tedious in specifying the construction of a building. Either of

these choices works though because consistent data for temperature and pressure are available from the Weather Service for either case.

Examples:

```
TAMB 300
TAMB 288 101000 200.
```

The first example sets the ambient temperature to 300 K, but leaves the ambient pressure at 101300 and the reference elevation at 0 m. The second specifies a temperature of 288 K (15 °C) at 200 m and a pressure of 101000 Pa. In both of these cases the external ambient is set to the same values. An example of different inside and outside values is a warm building in a winter setting and might be described as

```
TAMB   288 101305 0.0
EAMB   270 101315 0.0
```

4.4.3 Floor Plan Data

The floor plan data section allows the user to portray the geometry of the structure being modeled. The size and location of every room in the structure MUST be described. The maximum number of rooms is dependent upon the local implementation of FAST. Usually a total of 10 rooms (plus the outdoors) is available for a single simulation. For the PC versions, a maximum of six compartments (plus the outdoors) is allowed. The structure of the data is such that the compartments are described as entities, and then connected in appropriate ways. It is thus possible to have a set of rooms which can be configured in a variety of ways. In order to specify the geometry of a building, it is necessary to give its physical characteristics. Thus the lines labelled HI/F, WIDTH, DEPTH AND HEIGH are all required. Each of these lines requires "N" data entries, that is one for each compartment.

Keyword:	HI/F
Input:	Floor Height

Floor Height (m)	The floor height is the height of the floor of each room with respect to station elevation specified by the TAMB parameter. The reference point must be the same for all elevations in the input data. The number of values on the line must equal the number of rooms in the simulation.

Keyword:	WIDTH
Input:	Room Width

Room Width (m)	Room width specifies the width of the room. The number of values on the line must equal the number of rooms in the simulation.

Keyword:	DEPTH
Input:	Room Depth

Room Depth (m)	Room depth specifies the depth of the room. The number of values on the line must equal the number of rooms in the simulation.

Keyword:	HEIGH
Input:	Room Height

Room Height (m)	Room Height specifies the height of the room. The number of values on the line must equal the number of rooms in the simulation.

Example:

```
HI/F    0.0    0.0    0.0
WIDTH   6.1    4.6    4.6
DEPTH   9.1   14.3    4.3
HEIGH   3.6    2.4    2.4
```

This floor plan data specifies the sizes for a three room simulation with rooms sizes of 6.1 x 9.1 x 3.6 m, 4.6 x 14.3 x 2.4 m, and 4.6 x 4.3 x 2.4 m, respectively. All rooms are at the same elevation at a reference height of 0.0 m.

4.4.4 Connections

The connections section of the input data file describes any horizontal or vertical vents between rooms in the structure. These may include doors between rooms in the structure, windows in the rooms (between rooms or to the outdoors), or vertical openings between floors of the structure. Openings to the outside are included as openings to the room with a number one greater than the number of rooms described in the floor plan data section. Doors, windows, and the like are called horizontal vents because the direction of the vent, or vent connection, is in the horizontal direction. The key word is HVENT. Horizontal vents may be opened or closed during the fire with the use of the CVENT key word. For vertical vents, such as scuddles, the key word is VVENT; at present there is not an equivalent mechanism for opening or closing the vertical vents. The form for horizontal and vertical vents is necessarily different.

Keywords:	HVENT
Inputs:	First Room, Second Room, Vent Number, Width, Soffit, Sill, Wind

Required to specify connections between compartments. No openings prevents flow. Each HVENT line in the input file describes one horizontal vent between rooms in the structure (or between a room and the outdoors). The first six entries on each line are required. There is an optional seventh parameter to specify a wind coefficient.

First Room	The first room is simply the first connection.
Second Room	The second room is the room number to which the first room is connected. The order has one significance. The height of the sill and soffit are with respect to the first compartment specified.
Vent Number	There can be as many as four vents between any two compartments. This number specifies which vent is being described. It can range from one to four.
Width (m)	The width of the opening.
Soffit (m)	Position of the top of the opening above the floor of the room number specified as the first room.
Sill (m)	Sill height is the height of the bottom of the opening above the floor of the room number specified as the first room.

Wind	The wind coefficient is the cosine of the angle between the wind vector and the vent opening. This applies only to vents which connect to the outside ambient (specified with EAMB). The range of values is -1.0 to +1.0. If omitted, the value defaults to zero.

Keywords:	VVENT
Inputs:	First Room, Second Room, Area

Required to specify a vertical connection between compartments. Each VVENT line in the input file describes one vertical vent between rooms in the structure (or between a room and the outdoors). There are three parameters, the connected compartments, and the effective area of the vent.

First Room	The first room is simply the first connection.
Second Room	The second room is the room number to which the first room is connected.
Area (m^2)	This is the effective area of the opening. For a hole, it would be the actual opening. For a diffuser, then the effective area will be somewhat less than the geometrical size of the opening.

Examples:

```
HVENT 1   2   1 1.1   2.1   0.0
HVENT 1   3   1 1.1   2.1   0.0
HVENT 2   4   1 1.3   2.1   0.6
VVENT 1   3   3.0
```

Assuming the three room structure as described in the floor plan data section, the above examples describe two openings 1.1 x 2.1 m between rooms 1 and 2

and between rooms 1 and 3. An 1.3 x 2.1 m opening between room 2 and the outside (room 4 for a three room simulation) is raised 0.6 m off the floor of room 2.

```
HVENT 2   4   2 1.3   2.1   0.6 1.0
```

This specifies vent #2 between compartment (2) and the outside, with a wind coefficient of 1.0, which implies that the vent is facing directly into the wind.

CVENT is a parameter which is used to open a close vents. It multiples the width in the vent flow calculation. The default is 1.0 which is a fully open vent. A value of 0.5 would specify a vent which was halfway open.

Keyword:	CVENT
Input:	First Room, Second Room, Vent Number, Width
Specify closing value. Each CVENT line in the input file describes one horizontal vent between rooms in the structure (or between a room and the outdoors).	

First Room	The first compartment.
Second Room	The second room is the room number to which the first room is connected.
Vent Number	This number specifies which vent is being described. It can range from one to four. These parameters correspond to the first three parameters in HVENT.
Width	Fraction that the vent is open. This applies to the width only. The sill and soffit are not changed. A total of LFMAX + 1 width entries are included, one for each time interval.

CVENT has a form similar to HVENT but in addition contains the opening data. The additional data is in the same form as all the time dependent specifications, namely a value for each endpoint in the heat release curve. The form is

    CVENT C#1 C#2 V# x x x x,...

By way of example, the default value for CVENT for the example show above with LFMAX=5 would be

    CVENT 1 2 1 1.0 1.0 1.0 1.0 1.0 1.0

and would specify that the first vent between compartments (1) and (2) would be open at all times. Another example would be

    CVENT 1 3 1 0.5 0.5 0.5 0.5 0.5 0.5

and would specify that the first vent between compartments (1) and (3) would be half open all of the time. These fractions refer to the width given in the HVENT specification and for the cases above would be 1.1 me.

There are several key words which are used to describe the mechanical ventilation. The key words which apply to mechanical ventilation are

MVOPN -   describe an opening between a compartment and the ventila-
            tion system
MVDCT -   describe a piece of (circular) duct work
MVFAN -   give the pressure - flow relationship for a fan
INELV -   specify interior node elevations

Keyword:	MVOPN
Inputs:	Compartment Number, Duct Work Node Number, Orientation, Height, Area

Connect a compartment to a node in the mechanical ventilation system.

Compartment Number	Specify the compartment number.
Duct Work Node Number	Corresponding node in the mechanical ventilation system to which the compartment is to be connected.
Orientation	V for vertical or H for horizontal.
Height (m)	Height of the duct opening above the floor of the compartment.
Area (m^2)	Area of the opening into the compartment.

Keyword:	MVDUCT
Inputs:	First Node Number, Second Node Number, Length, Diameter, Absolute Roughness, First Flow Coefficient, First Area, Second Flow Coefficient, Second Area

Specify a piece of duct work.

First Node Number	First node number. This is a node in the mechanical ventilation scheme, not a compartment number (see MVOPN).
Second Node Number	Second node number.

Length (m)	Length of the duct.
Diameter (m)	All duct work is assumed to be circular. Other shapes must be approximated by changing the flow coefficient. This is done implicitly by network models of mechanical ventilation and forced flow, but must be done explicitly here.
Absolute Roughness (m)	Roughness of the duct.
First Flow Coefficient	Flow coefficient to allow for an expansion or contraction at the end of the duct which is connected to node number one. To use a straight through connection (no expansion or contraction) set to zero.
First Area (m^2)	Area of the expanded joint.
Second Flow Coefficient	Coefficient for second node.
Second Area (m^2)	Area at the second node.

Keyword:	MVFAN
Inputs:	First Node, Second Node, Minimum Pressure, Maximum Pressure, Coefficients

Specify fan curve with power law coefficients. There must be at least one coefficient.

First Node	First node in the mechanical ventilation system to which the fan is connected.
Second Node	Second node to which the fan is connected.
Minimum Pressure (Pa)	Lowest pressure of the fan curve. Below this value, the flow is assumed to be constant.
Maximum Pressure (Pa)	Highest pressure at which the fan will operate. Above this point, the flow is assumed to stop.
Coefficients	At least one, and a maximum of five coefficients to specify the flow as a function of pressure. See comments at the end of this section for more information.

Keyword: INELV
Inputs: Node Number, Height

Specify interior elevations of the mechanical ventilation nodes. All nodes
can be specified, but the exterior nodes, that is those connected to a
compartment, will be set to the compartment elevation. The heights are
absolute heights above the reference datum specified by TAMB. The
heights are specified in pairs, the node number followed by the height.

Node Number	Number of an interior node.
Height (m)	Height of the node.

Example 1:

```
MVDCT  1 3 20. .15 .19E-3  3.30  .01767  0. 0.
MVDCT  3 4 44. .2  .19E-3  0.0   0.0     0. 0.
MVFAN   4 5   0.0 140.   0.140 3.170E-04 -1.803E-05  1.898E-07 -8.104E-10
MVOPN  1 1 H 0. 1.
MVOPN  4 9 V 0. 2.5
INELV  3  0   4 0  5 0  7 0 8 0
```

Example 2:

```
MVDCT  1 3 20. .15 .19E-3  3.30  .01767  0. 0.
MVDCT  2 3 20. .15 .19E-3  2.94  .01767  0. 0.
MVDCT  3 4 44. .2  .19E-3  0.0   0.0     0. 0.
MVDCT  5 6 40. .2  .19E-3  .51   .03142  0. 0.
MVDCT  7 4 40. .2  .19E-3  .51   .03142  0. 0.
MVDCT  9 8 40. .2  .19E-3  .51   .03142  0. 0.
MVFAN   4 5   0.0 140.   0.140 3.170E-04 -1.803E-05  1.898E-07 -8.104E-10
MVFAN   8 7  0.0 140.   0.140 3.170E-04 -1.803E-05  1.898E-07 -8.104E-10
MVOPN  1 1 H 0. 1.
MVOPN  2 2 H 0. 1.5
MVOPN  3 6 H 0. 2.5
MVOPN  4 9 H 0. 2.5
INELV  3  0   4 0  5 0  7 0 8 0
```

This example describes a network which is shown in Figure 7.
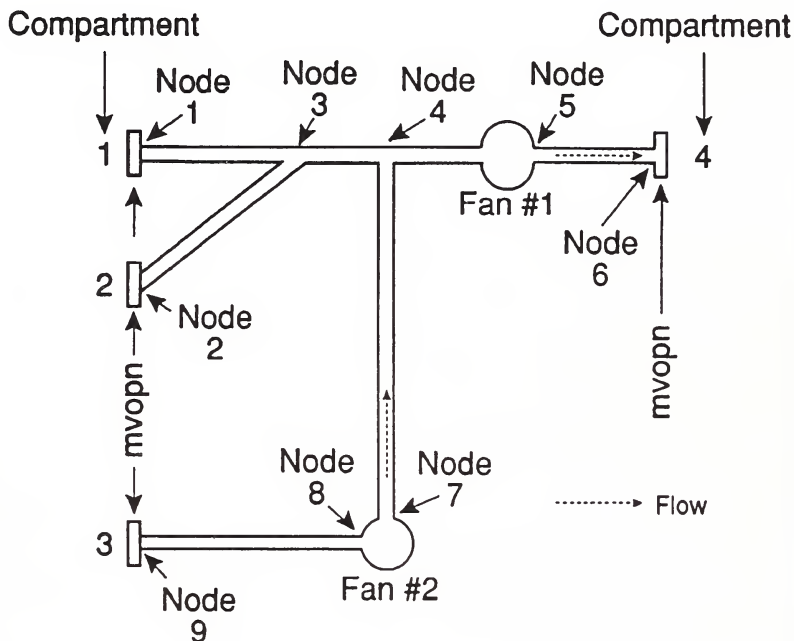
Figure 7. Node arrangement for example 2.

The fan coefficients are simple the coefficients of an interpolating polynomial for the flow speed as a function of the pressure across the fan housing. The fan described in the previous example was for a pressure range of zero to 140 Pascals. An example of such a calculation is the following:

The following data (flow in kilograms per second)

```
FLOW   .07 .07 .06 .06 .055 .05 .05 .045 .036 .031 .02
HEAD    0   35  60  70  80      90 100 110  120  130  140
```

produces the following coefficients

```
B( 1) =      0.700576E-01        b(1)
B( 2) =      0.393806E-03        b(2) x p
B( 3) =     -0.168848E-04        b(3) x p²
B( 4) =      0.171071E-06        b(4) x p³
B( 5) =     -0.634662E-09        b(5) x p⁴
```

which correlates with the original data as

| | | CALCULATED | PERCENT |
PRESSURE	FLOW	FLOW	DIFFERENCE
0.00	0.070	0.070	0.08
35.00	0.070	0.070	-0.66
60.00	0.060	0.062	2.71
70.00	0.060	0.058	-2.79
80.00	0.055	0.055	0.17
90.00	0.050	0.052	3.61
100.00	0.050	0.048	-3.61
110.00	0.045	0.044	-2.57
120.00	0.036	0.038	6.06
130.00	0.031	0.030	-1.69
140.00	0.020	0.020	-0.72

4.4.5 Thermophysical Properties of Enclosing Surfaces

The thermophysical properties of the enclosing surfaces are described by specifying the thermal conductivity, specific heat, emissivity, density, and thickness of the enclosing surfaces for each room. If the thermophysical properties of the enclosing surfaces are not included, FAST will treat them as adiabatic (no heat transfer). Since most of the heat conduction is through the ceiling and since the conduction calculation takes a significant fraction of the computation time, it is recommended that initial calculations be made using the ceiling only. Adding the walls generally has a small effect on the results and the floor contribution is usually negligible. Clearly, there are cases where the above generalization does not hold, but it may prove to be a useful screening

technique. Currently, thermal properties for materials are read from a thermal database file unique to FAST. The data in the file simply gives a name (such as CONCRETE) which is a pointer to the properties in the thermal database. All of these specifications are optional. The thermal properties are assumed to be constant; that is, we do not account for the variation with temperature or water content.

The thermophysical properties are specified at *one* condition of temperature, humidity, etc. There can be as many as three layers per boundary, but they are specified in the thermal database itself.

Keyword:	CEILI	
Inputs:	Ceiling Materials	
Ceiling Materials	The label CEILI indicates that the names of thermo-physical properties on this line describe the ceiling material. If this parameter is present, there must be an entry for each compartment.	

Keyword:	WALLS	
Inputs:	Wall Materials	
Wall Materials	The label WALLS indicates that the names of thermophysical properties on this line describe the wall material. If this parameter is present, there must be an entry for each compartment.	

Keyword:	FLOOR
Inputs:	Floor Materials

Floor Materials	The label FLOOR indicates that the names of thermophysical properties on this line describe the floor material. If this parameter is present, there must be an entry for each compartment.

Examples:

```
CEILI  OFF         REDOAK      CONCRETE
WALLS  CONCRETE    CONCRETE    CONCRETE
```

The corresponding thermal data base might appear as

```
CONCRETE    1.75   1000.    2200.    0.1500   0.94
BRICK       0.18    900.     790.    0.016    0.90
REDOAK      0.15   1300.     640.    0.025    0.99
```

The names of the materials can be any ASCII string up to 8 characters. So a valid name is $%#@**% although this admittedly does not convey much information. The key word "OFF" is used to tell the model not to compute the heat loss for the ceiling in compartment (1). In this case the FLOOR parameter is not present at all, so there will be no heat transfer through the floor in any room and the calculation will not be done for the ceiling in compartment (1), where the key word "OFF" is present. This is most useful for doing the heat transfer calculation in the burn room and adjacent rooms and then turning it off in distant compartments.

Thermal data is read from a file which is in an ASCII format. The default name used is THERMAL.TPF. Another name can be used by selecting it during installation, or by using the key word THRMF in the FAST data file. The relationship is by the name used in specifying the boundary. The example

shown above was for concrete, brick and red oak. Any name can be used so long as it is in the thermal database. If a name is used which is not in the database, then FAST_in will turn off the conduction calculation, and FAST will stop with an appropriate error message. The form of an entry in the database is

name conductivity specific heat density thickness emissivity

and the units are

name	1 to 8 alphanumeric characters
conductivity	Watts/meter/Kelvin
specific heat	Joules/kilogram/Kelvin
density	kilograms/cubic meter
thickness	meters
emissivity	dimensionless.

The default database that comes with FAST (THERMAL.TPF) is

Name	Conductivity	Specific heat	Density	Thickness	Emissivity
DFIR30	0.1800	900.0	790.0	0.0160	0.9000
PINEWOOD	0.1200	2500.0	540.0	0.0160	0.8000
CONCRETE	1.75	1000.0	2200.0	0.1500	0.9400
REDOAK	0.1500	1300.0	640.0	0.0160	0.9000
FIBER	0.0500	1250.0	240.0	0.0160	0.9000
GYPSUM	0.1600	900.0	800.0	0.0160	0.9000
WOOD	0.0700	1000.0	250.0	0.0160	0.9800
DFIR0	0.1300	1400.0	510.0	0.0127	1.00
DFIR10	0.1500	1500.0	560.0	0.0160	0.9000
GLASS	1.40	760.0	2500.0	0.0160	0.9500
GLASFIBR	0.0360	720.0	32.0	0.0160	0.9000
KAOWOOL	0.2200	1047.0	128.0	0.1160	0.9700
GYP1	0.1200	900.0	800.0	0.0250	0.9000
GYP2	0.1200	900.0	800.0	0.0500	0.9000
BRICK	0.1800	900.0	790.0	0.0160	0.9000

The output listing of FAST, and the thermal data base screen for FAST_in show a table of "codes." The code is an eight character string whose fields are

1-3	number of nodes if it exceeds 'NN' which is currently 48 (36 for the PC version)
4	always blank
5	too many slabs - greater than mxslb (S)
6	inconsistent number of slabs - all properties must have the same number of slabs (I)
7	duplicate names - the first in the list will be used (D)
8	used in the present calculation (U)

4.4.6 Fire Specifications

The fire specifications allow the user to describe the fire source in the simulation. The location and position of the fire is specified along with the chemical properties of the fuel. Finally, the fire is described with a series of mass loss rate, fuel height, and fuel area inputs. All of these specifications are optional and each line requires a single number. The defaults for the fire specification is a methane burner in the center of compartment (1). The defaults shown for each key word reflect the values for methane.

Keyword:	LFBO
Input:	Room of Fire Origin
Room of Fire Origin	Room of fire origin is the room number in which the fire originates. Default is 1.

Keyword:	LFBT
Input:	Fire Type

Fire Type	This is a number indicating the type of fire. 1 Unconstrained fire 2 Constrained fire. The default is 1. See sections 4.5 and 5.5 for a discussion of the implications of this choice.

Keyword:	LFPOS
Input:	Fire Position

Fire Position	The fire position is the area of the room in which the fire originates and is one of the following values: 1 Center of the room, 2 Corner of the room, or 3 Along a wall of the room, but not near a corner of the room. The fire position is used to account for the entrainment rate of the plume, which depends on the location of the fire plume within the compartment. Fire positions 2 and 3 should only be used when the fire is very close to the corner or wall respectively. The default is 1.

Keyword:	CHEMI
Inputs:	Molar Weight, Relative Humidity, Limiting Oxygen Index, Heat of Combustion, Initial Fuel Temperature, Gaseous Ignition Temperature

Chemical kinetics and miscellaneous parameters.	
Molar Weight	Molecular weight of the fuel vapor. This is the conversion factor from mass density to molecular density for "tuhc." Default is 16. It is used only for conversion to ppm, and has no effect on the model itself.
Relative Humidity (%)	The initial relative humidity in the system. This is converted to kilograms of water per cubic meter from the table from "Dynamical and Physical Meteorology" by Haltiner and Martin (1957)
Limiting Oxygen Index (%)	The limit on the ratio of oxygen to other gases in the system below which a flame will not burn. This is applicable only to type (LFBT) 2 or later fires. The default is 10.
Heat of Combustion (J/kg)	Heat of combustion of the fuel. Default is 50000000.
Initial Fuel Temperature (K)	Typically, the initial fuel temperature is the same as the ambient temperature as specified in the ambient conditions section.
Gaseous Ignition Temperature (K)	Minimum temperature for ignition of the fuel as it flows from a compartment through a vent into another compartment. The default is the initial fuel temperature.

Keyword:	LFMAX
Input:	Number of Intervals

Number of Intervals	This is the number of time intervals for the mass loss rate, fuel height and species inputs. The mass loss rate, fuel height and species are entered as series of points with respect to time. This is referred to in this document as a specified fire. A sufficient number of intervals should be selected to provide a reasonable approximation (using straight line segments) for the input variables which specify the fire. A example of this is shown in . The mass loss rates P_1-P_7 are specified over the time intervals I_1-I_6. The number of points specified must be one greater than the number of time intervals. For example, if there are six mass loss points there should be a total of five time intervals (or one interval between every two consecutive points). The maximum number of intervals allowed in version 18 of FAST is 21.
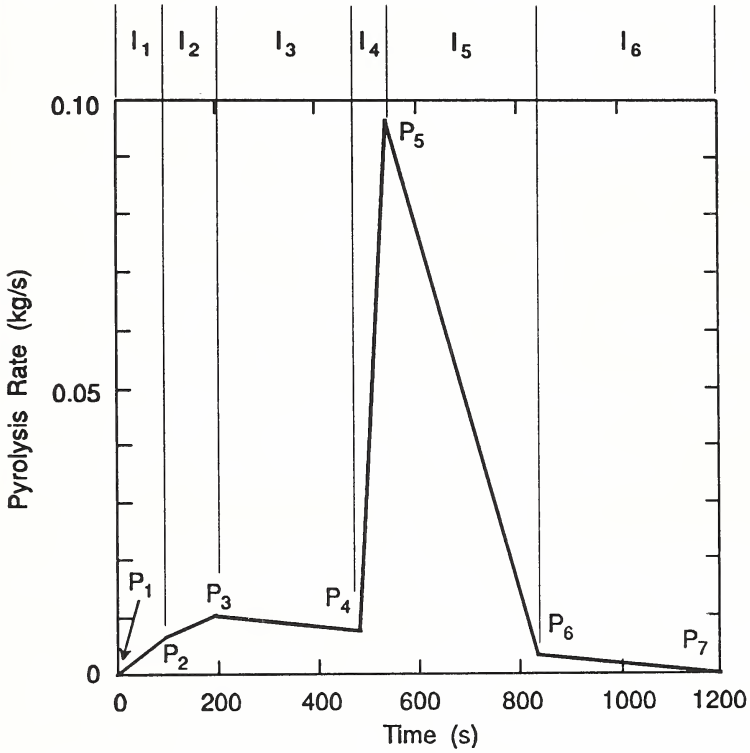
Figure 8. Straight line approximation of a specified fire.

Keyword:	FTIME
Inputs:	Time Interval

A total of LFMAX Time Intervals must be included on this input line.

Time Interval **(s)**	Time interval is the time between each point (mass loss rate, fuel height and species) specified for the fire. The total duration of the fire is the sum of the time intervals. This time is independent of the simulation time which is specified for the TIMES label. If the simulation time is longer than the total duration of the fire, the final values specified for the fire (mass loss rate, fuel height, fuel area, and species) will be continued until the end of the simulation. The number of values on the line must equal the number of time intervals specified by LFMAX, above.

Keyword:	FMASS
Inputs:	Mass Loss Rate

A total of LFMAX+1 Mass Loss Rates must be included on this input line.

Mass Loss Rate **(kg/s)**	The rate at which fuel is pyrolyzed at times corresponding to each point of the specified fire.

Keyword:	FHIGH
Inputs:	Fuel Height

A total of LFMAX + 1 Fuel Heights must be included on this input line.

Fuel Height (m)	The height of the base of the flames above the floor of the room of fire origin for each point of the specified fire.

Keyword:	FQDOT
Inputs:	Heat Release Rate

A total of LFMAX + 1 Heat Release Rates must be included on this input line.

Heat Release Rate (W)	The heat release rate of the specified fire.

With the three parameters, the heat of combustion (HOC) from CHEMI, FMASS and FQDOT, the pyrolysis and heat release rate are over specified. The model uses the last two of the three to obtain the third parameter. That is, if the three were specified in the order HOC, FMASS and FQDOT, then FQDOT would be divided by FMASS to obtain the HOC for each time interval. If the order were FMASS, FQDOT and HOC, then the pyrolysis rate would be determined by dividing the heat release rate by the heat of combustion. If only two of the three are given, then those two will determine the third, and finally, if none or only one of the parameters is present, the defaults shown will be used.

Example:

```
LFBO     1
LFBT     1
LFPOS    1
CHEMI    0.0  0.0 10.   18100000. 300.
LFMAX    7
FMASS    .014   .0014 .025  .045   .050   .0153 .0068 .0041
FAREA    .5     .5    .5    .5     .5     .5    .5    .5
FHIGH    .25    .25   .25   .25    .25    .25   .25   .25
FTIME       20.   20.   50.    50.  100.  100.  400.
```

In the example, a specified fire (LFBT 1) originates in room number 1 (LFBO 1) in the center of the room (LFPOS 1). A seven segment (LFMAX) fire is specified. The fuel burns with a heat of combustion of 18100000 J/kg. The initial relative humidity is 0%, the molecular weight is 16 (zero is not allowed, so the default is used) and the limiting oxygen index is 10%. Since the type of fire is 1, an unconstrained fire, this latter parameter has no meaning in this context.

```
LFBT     2
LFMAX    7
FMASS    .014   .0014 .025  .045   .050   .0153 .0068 .0041
FAREA    .5     .5    .5    .5     .5     .5    .5    .5
FHIGH    .25    .25   .25   .25    .25    .25   .25   .25
FTIME       20.   20.   50.    50.  100.  100.  400.
```

In this example, the specified fire is constrained with a limiting oxygen index of 10% (the default since CHEMIE is not given). Since LFBO is not given, the default compartment (1) is used, and the position of the fire is in the center of the room. The default heat of combustion of 50000000 kJ/kg is used.

4.4.7 Species Production

Species production rates are specified in the manner similar to the fire, entering the rates as a series of points with respect to time. The species which are followed by FAST are

- Carbon Dioxide
- Carbon Monoxide
- Concentration-Time Product
- Hydrogen Cyanide
- Hydrogen Chloride
- Nitrogen
- Oxygen
- Soot (Smoke Density)
- Total Unburned Hydrocarbons
- Water

For a type one (LFBT=1) fire, only the concentration-time product of pyrolysate(ct), hydrogen cyanide(hcn) and hydrogen chloride(hcl) can be specified. No other species are followed. For a type two (LFBT=2) fire, nitrogen, oxygen, carbon dioxide, carbon monoxide, soot, unburned fuel and water are followed. In all cases, the unit of the production rates is kg/kg. However, the meaning of the production rates is different for the several types of species. For either fire, the production rates for ct, hcn and hcl are with respect to the pyrolysis rate of the fuel. For the others, carbon monoxide, water, etc., the production rate is specified with respect to the basic carbon production in the form of a ratio with carbon dioxide. For carbon monoxide, for example, the specification will be CO/CO_2. Thus we can not consider a pure hydrogen flame, but this is unlikely in the situations of interest.

Keywords: HCN, HCL, or CT
Input: Production Rate

For each species desired a series of production rates are specified for each of the time points input for the specified fire. The program performs a linear interpolation between these points to determine the time of interest.

Production Rate (kg/kg)	Units are kilogram of species produced per kilogram of fuel burned. The input for CT is the kilograms of "toxic" combustion products produced per kilogram of fuel burned.

Keywords: HCR or O2
Input: Production Rate of the Fuel

For each species desired a series of production rates are specified for each of the time points input for the specified fire. The program performs a linear interpolation between these points to determine the time of interest.

Production Rate of the Fuel (kg/kg)	The mass ratio of hydrogen to carbon (for HCR) or oxygen to carbon (for O2) *as it becomes available from the fuel.*

Keyword: OD
Input: Yield

For each species desired a series of production rates are specified for each of the time points input for the specified fire. The program performs a linear interpolation between these points to determine the time of interest.

Yield (kg/kg)	The ratio of the mass of carbon to carbon dioxide produced by the oxidation of the fuel.

Keyword: CO
Input: Yield

For each species desired a series of production rates are specified for each of the time points input for the specified fire. The program performs a linear interpolation between these points to determine the time of interest.

Yield (kg/kg)	The ratio of the mass of carbon monoxide to carbon dioxide produced by the oxidation of the fuel.

4.4.8 Files

There are several files which FAST uses to communicate with its environment. They are 1) a configuration file, 2) the thermal database, 3) a "dump" file, and 4) a restart file. The output of the simulation may be written to a disk file for further processing by programs such as FASTplot or to restart FAST. At each interval of time as specified by the dump interval in the TIMES label, the output is written to the file specified. For efficient disk storage and optimum speed, the data is stored in an internal format and cannot be read directly with a text editor.

Keyword:	DUMPR
Input:	Dump File
Dump File	The name specifies a file (up to 17 characters) to which the program outputs for plotting are written. Dump file is an optional input. If omitted, the file will not be generated. Note that in order to obtain a history of the variables, this parameter must be specified and also the dumper interval (under TIMES) must be set to a non-zero value.

Keyword:	RESTR
Input:	Restart File, Restart Time
Restart File	The name specifies a file (up to 17 characters) from which the program reads data to restart the model. This data must have been generated (written) previously with the dump parameter discussed earlier.
Restart Time (s)	A time step is given after the name of the file and specifies at what time the restart should occur.

Keyword:	THRMF
Input:	Thermal Database
Thermal Database	The name specifies a file (up to 20 characters) from which the program reads thermophysical data. If this parameter is not specified, then either the default (THERMAL.DAT) is used, for the name is read from the configuration file.

Keyword:	DEFCG
Input:	Configuration File
Configuration File	The name specifies a file (up to 20 characters) from which the program reads configuration information data.

Example:

```
DUMPR FAST1.DAT
RESTR filename n
THRMF thermal.tpf
```

where "filename" was created in a previous run using the DUMP parameter. "n" specifies the starting time and must be one of the times at which a dump was generated. As an example, if a data set were run with

```
        VERSN    18 title...
        TIMES    360 60 10 0 0
        .
        .
        DUMPR    MYFILE
```

then every 10 s a snap shot of the time histories of all variables would be generated. A restart might be done at 300 s with the following

```
VERSN   18 new title
TIMES   900 60 0 0 0
.
.
.
RESTRT  MYFILE 300
```

with no requirement that the restart must be at the last dump point. The only caveat is to check the listings to be sure that a dump was generated at the desired point. For those cases where too many dump intervals are requested, the interval is recalculated, and a message is written to the output device.

4.4.9 Graphics Specification

A graphics specification can be added to the data file. Details of the meaning of some of the parameters is best left to the discussion of the device independent graphics software used by FAST [2]. However, the information necessary to use it is straightforward. The general structure is similar to that used for the building and fire specification. One must tell the program "what to plot," "how it should appear," and "where to put it."

The key words for "where to put it" are

DEVICE	where to plot it
BAR	bar charts
GRAPH	specify an x-y plot
TABLE	put the data into a table
PALETTE	specify the legend for CAD views
VIEW	show a perspective picture of the structure
WINDOW	the size of the window in "user" space.

The complete key word is required. That is, for the "where to put it" terms, no abbreviations are allowed. Then one must specify the variables to be plotted. They are

VENT, HEAT, PRESSUR, WALL, TEMPERA, INTERFA,
H_2O, CO_2, CO, OD, O_2, TUHC, HCN, HCL, CT

As might be expected, these are the similar key words to those used in the plotting program, FASTplot. In this case, we have a reduced set. The application and use of FAST and FASTplot are different.

For each key word there are parameters to specify the location of the graph, the colors and finally titles as appropriate. For the variables, there is a corresponding pointer to the graph of interest.

The form of each "where to put it" variable is described below

Keyword:	DEVICE
Input:	Plotting Device
Plotting Device	The Plotting Device specifies the hardware device where the graphics is to be displayed. For the PC version, this key word should be omitted. If it must be included for compatibility reasons, set it to 4. For other computers, it is installation dependent. In general it specifies which device will receive the output.

Keyword:	WINDOW
Inputs:	Xl, Yb, Zf, Xr, Yt, Zb

The window label specifies the user space for placement of graphs, views,... The most common values (which are also the default) are

Xl = 0., Yb = 0., Zf = 0.
Xr = 1279., Yt = 1023., Zb = 10.

This is not a required parameter; however, it is often convenient to define graphs in terms of the units that are used. For example, if one wished to display a house in terms of a blueprint, the more natural units might be feet. In that case, the parameters might have the values

Xl = 0., Yb = 0., Zf = 0.
Xr = 50., Yt = 25., Zb = 30.

Xl	left hand side of the graph in any user desired units.
Yb	bottom of the graph in any user desired units.
Zf	forward edge of the 3D block in any user desired units.
Xr	right hand side of the graph in any user desired units.
Yt	top of the graph in any user desired units.
Zb	rear edge of the 3D block in any user desired units. These definitions refer to the 3D plotting block that can be seen.

Keyword:	GRAPH
Inputs:	Graph Number, Xl, Yb, Zf, Xr, Yt, Zb, Color, Abscissa Title, Ordinate Title

Up to five graphs may be displayed at one time on the graphics display. Each graph is identified by a unique number (1-5) and placed in the window at a specified location. Xl,Yb,Zf,Xr,Yt and Zb have a meaning similar to WINDOW. However, here they specify where in the window to put the graph.

Graph Number	The number to identify the graph. Allowable values are from 1 to 5. The graphs must be numbered consecutively, although they do not have to be given in order. It is acceptable to define graph 4 before graph 2 but if graph 4 is to be used, then graphs 1 through 3 must also be defined.
Xl	Left hand side of the graph within the window in the same units as that of the window.
Yb	Bottom of the graph within the window in the same units as that of the window.
Zf	Forward edge of the 3D (three dimensional) block within the window in the same units as that of the window.
Xr	Right hand side of the graph within the window in the same units as that of the window.
Yt	Top of the graph within the window in the same units as that of the window.
Zf	Back edge of the 3D block within the window in the same units as that of the window.

Color	The color of the graph and labels which is specified as an integer from 1 to 15. Refer to DEVICE (NBSIR 85-3235) for the colors corresponding to the values for the color.
Abscissa Title	Title for the abscissa (horizontal axis). To have blanks in the title, use the underscore character "_".
Ordinate Title	Title for the ordinate (vertical axis). To have blanks in the title, use the underscore character "_".

Keyword:	TABLE
Inputs:	Table Number, Xl, Yb, Zf, Xr, Yt, Zb

Up to five tables may be displayed at one time on the graphics display. Each table is identified by a unique number and placed in the window at a specified location. Xl,Yb,Zf,Xr,Yt and Zb have a meaning similar to WINDOW. However, here they specify where in the window to put the table.

Table Number	The table number is the number to identify the table. Allowable values are from 1 to 5. The tables must be numbered consecutively, although they do not have to be given in order. It is acceptable to define table 4 before table 2 but if table 4 is to be used, then tables 1 through 3 must also be defined.
Xl	Left hand side of the table within the window in the same units as that of the window.
Yb	Bottom of the table within the window in the same units as that of the window.

Zf	Forward edge of the 3D block within the window in the same units as that of the window.
Xr	Right hand side of the table within the window in the same units as that of the window.
Yt	Top of the table within the window in the same units as that of the window.
Zb	Back edge of the 3D block within the window in the same units as that of the window.

Keyword: VIEW
Inputs: View Number, Xl, Yb, Zf, Xr, Yt, Zb, File, Transform Matrix

Up to five views may be displayed at one time on the graphics display. Each view is identified by a unique number and placed in the window at a specified location. Xl, Yb, Zf, Xr, Yt and Zb have a meaning similar to WINDOW. However, here they specify where in the window to put the view.

View Number	View number is the number to identify the view. Allowable values are from 1 to 5. The views must be numbered consecutively, although they do not have to be given in order. It is acceptable to define view 4 before view 2 but if view 4 is to be used, then views 1 through 3 must also be defined.
Xl	Left hand side of the view within the window in the same units as that of the window.
Yb	Bottom of the view within the window in the same units as that of the window.

Zf	Forward edge of the 3D block within the window in the same units as that of the window.
Xr	Right hand side of the view within the window in the same units as that of the window.
Yt	Top of the view within the window in the same units as that of the window.
Zf	Back edge of the 3D block within the window in the same units as that of the window.
File	File is the filename of a compatible "BUILD" file, as discussed later.
Transform Matrix	The Transform Matrix is a 16 number matrix which allows dynamic positioning of the view within the window. The matrix (1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1) would show the image as it would appear in a display from BUILD.

| Keyword: | PALETTE |
| Inputs: | Palette Number, Xl, Yb, Zf, Xr, Yt, Zb, Color and Label |

The PALETTE label performs a specialized function for showing colors on the views. A four entry table is created and used for each type of filling polygon used in a view. Up to five palettes may be defined. Each palette is identified by a unique number and placed in the window at a specified location. Xl, Yb, Zf, Xr, Yt and Zb have a meaning similar to WINDOW. However, here they specify where in the window to put the palette.

Palette Number	Palette number is the number to identify the palette. Allowable values are from 1 to 5.
Xl	Left hand side of the palette within the window in the same units as that of the window.
Yb	Bottom of the palette within the window in the same units as that of the window.
Zf	Forward edge of the 3D block within the window in the same units as that of the window.
Xr	Right hand side of the palette within the window in the same units as that of the window.
Yt	Top of the palette within the window in the same units as that of the window.
Zb	Back edge of the 3D block within the window in the same units as that of the window.

Color and Label	There are four pairs of color/text combinations, each corresponding to an entry in the palette. The color number is an integer from 1 to 15 and the text can be up to 50 characters (but remember the 128 character maximum). As before, spaces are indicated with an underscore character "_".

Keyword: BAR
Inputs: Bar Chart Number, Xl, Yb, Zf, Xr, Yt, Zb, Abscissa
                Title, Ordinate Title

Up to five bar charts may be displayed at one time on the graphics display. Each bar chart is identified by a unique number and placed in the window at a specified location. Xl, Yb, Zf, Xr, Yt and Zb have a meaning similar to WINDOW. However, here they specify where in the window to put the bar chart.

Bar Chart Number	The number to identify the bar chart. Allowable values are from 1 to 5.
Xl	Left hand side of the bar chart within the window in the same units as that of the window.
Yb	Bottom of the bar chart within the window in the same units as that of the window.
Zf	Forward edge of the 3D block within the window in the same units as that of the window.
Xr	Right hand side of the bar chart within the window in the same units as that of the window.
Yt	Top of the bar chart within the window in the same units as that of the window.

Zb	Back edge of the 3D block within the window in the same units as that of the window.
Abscissa Title	Title for the abscissa (horizontal axis). To have blanks in the title, use the underscore character "_".
Ordinate Title	Title for the ordinate (vertical axis). To have blanks in the title, use the underscore character "_".

Keyword: LABEL
Inputs: Label Number, Xl, Yb, Zf, Xr, Yt, Zb, Text, Angle1, Angle2

Up to five labels may be displayed at one time on the graphics display. Each label is identified by a unique number and placed in the window at a specified location. Xl, Yb, Zf, Xr, Yt, and Zb have a meaning similar to WINDOW. However, here they specify where in the window to put the label. It is assumed that time is always to be displayed if any labels are present. To this end, label 1 is always used for the time in the units HH:MM:SS.

Label Number	Label number is the number to identify the label. Allowable values are from 1 to 5.
Xl	Left hand side of the label within the window in the same units as that of the window.
Yb	Bottom of the label within the window in the same units as that of the window.
Zf	Forward edge of the 3D block within the window in the same units as that of the window.
Xr	Right hand side of the label within the window in the same units as that of the window.

Yt	Top of the label within the window in the same units as that of the window.
Zb	Back edge of the 3D block within the window in the same units as that of the window.
Text	The text to be displayed within the label. To have blanks in the title, use the underscore character "_".
Color	Color of the text to be displayed (a number from 0 to 15).
Angle1 and Angle2	Angles for display of the label in a right cylindrical coordinate space. At present only the first angle is used and represents a positive counterclockwise rotation; set the second angle to zero. Both angles are in radians.

In order to see the variables, they must be assigned to one of the above displays. This is accomplished with the variable pointers as

(Variable) (nmopq) (Compartment) (Layer).

Variable is one of the available variables VENT, HEAT, PRESSUR, WALL, TEMPERA, INTERFA, N_2, O_2, CO_2, CO, HCN, HCL, TUHC, H_2O, OD, CT used as a label for the line. The species listed correspond to the variable "SPECIES" in FASTplot. (nmopqr) is a vector which points to

```
index    display in

(1) n -> bar chart
(2) m -> table
(3) o -> view
(4) p -> label
(5) q -> graph
```

188

respectively. These numbers vary from 1 to 5 and correspond to the value of "n" in the "where to put it" specification. Compartment is the compartment number of the variable and Layer is "U" or "L" for upper and lower layer, respectively.

Examples:

```
WINDOW    0   0 -100  1280  1024    1100
GRAPH 1  250. 170.  0. 1220. 900.   10.  5 TIME   CELSIUS
LABEL 1  970. 960.  0. 1231. 1005.  10. 15 00:00:00                0.  0.
LABEL 2  690. 960.  0.  987. 1005.  10. 13 TIME_[S]                0.  0.
LABEL 3   90. 920.  0.  730. 1020.  10.  4 Single_Compartment_demo 0.  0.
LABEL 4  400. 610.  0.  687. 660.   10.  1 U_layer_temperature     .1  0.
LABEL 5  400. 270.  0.  687. 320.   10.  1 l_layer_temperature     .0  0.
TEMPERA 0 0 0 0 1    1 U
TEMPERA 0 0 0 0 1    1 L
```

In this case, a new window is defined, along with one graph and five labels. Both temperature variables are assigned to graph 1. One quirk is not obvious. It is assumed that time is always to be displayed if any labels are present. To this end, label 1 is always used for the time in the units HH:MM:SS. Graph 1 has the label "TIME" on the abscissa and "CELSIUS" on the ordinate.

```
WINDOW     0    0  -100 1280  1024   1100
GRAPH   1 120.  300.   0.  600.  920.  10.  3 TIME   PPM
GRAPH   2 740.  300.   0. 1220.  920.  10.  3 TIME   CELSIUS
LABEL   1 970.  960.   0. 1231. 1005.  10. 15 00:00:00         0.       0.
LABEL   2 690.  960.   0.  987. 1005.  10. 13 TIME_[S]         0.       0.
LABEL   3 200.  050.   0.  520.  125.  10.    14 CO¦D2¦O_CONCENTRATION 0. 0.
CO        0 0 0 0 1    1 U
TEMPERA 0 0 0 0 2    1 U
TEMPERA 0 0 0 0 2    1 L
```

This file sets up two graphs with the CO data from the upper layer of compartment (1) in the first graph and both the upper and lower layer temperatures displayed on the second graph.

```
WINDOW     0    0  -100 1280  1024   1100
GRAPH   1 150.  300.   0.  620.  920.  10.  3 TIME   PPM
LABEL   1 390.  960.   0.  651. 1005.  10. 15 00:00:00         0.       0.
LABEL   2 110.  960.   0.  407. 1005.  10. 13 TIME_[S]         0.       0.
LABEL   3 200.  050.   0.  520.  125.  10.    14 O¦D2¦O_CONCENTRATION 0. 0.
```

```
TABLE   1  700.  300.      0. 1200.  920.    10.
HEAT     0 1 0 0 0    1 U
O2       0 1 0 0 1    1 U
TEMPERA  0 1 0 0 0    1 U
TEMPERA  0 1 0 0 0    1 L
```

Here the four variables HEAT, O2, and TEMPERATURE are displayed in table 1 and O2 is shown in graph 1.

```
WINDOW      0      0  -100  1280  1024   1100
VIEW    1  800.  390.  150. 1200.  900.  200. DEMOFA.DAT 1.41 .48 1.33 0....
VIEW    2  420.  200.   50.  720.  500.  100. DEMOFA.DAT 1.53 -.46 1.21 0. ...
GRAPH   1   50.  290.    0.  300.  490.   10. 13 TIME   PPM
GRAPH   2  150.  650.    0.  500.  850.   10. 13 TIME   m¦U-1
GRAPH   3  510.  690.    0.  740.  890.   10. 13 TIME   CELSIUS
GRAPH   4  810.  120.    0. 1160.  320.   10. 13 TIME   HEIGHT
LABEL   1  760.  960.    0. 1021. 1005.   10. 14 00:00:00        0.      0.
LABEL   2   50.   10.    0.  250.   70.   10.  2 TEST_IN_ONE_ROOM   0.57079 0.
LABEL   3   70.  960.    0.  367. 1005.   10. 13 FIRE_[W]          0.      0.
LABEL   4  480.  960.    0.  777. 1005.   10. 13 TIME_[S]          0.      0.
LABEL   5  300.  960.    0.  475. 1005.   10. 14 _____          0.      0.
TABLE   1  220.   50.    0.  520.  250.   10.
HEAT     0 0 0 5 0    1 U
CO       0 1 1 0 0    1 U
CO       0 0 2 0 2    1 U
CO       0 1 1 0 1    1 U
CO       0 0 2 0 0    1 U
TEMPERA  0 1 1 0 3    1 U
TEMPERA  0 0 2 0 0    1 U
INTERFA  0 1 1 0 4    1 U
INTERFA  0 0 2 0 0    1 U
```

Two views are specified, both emanating from the file "demofa.dat" with different transforms. Four graphs, three labels and one table will be displayed. All variables will be taken from the upper layer in compartment (1), and they will go to both views, in determining the hazard calculation. The variables will also be shown in table 1 and in the four graphs, respectively.

4.5 FAST_in

FAST_in is a highly interactive, user-friendly program used to generate most data files for input to the FAST model. As such, it is difficult to describe all the functions of the program in a reference guide. Rather, it is best learned through use. Chapters 2 and 3 provide such a learning guide. This section will describe the types of information entered on each of the screens of FAST_in and relate those to the specific sections which describe the FAST input file generated by FAST_in.

The user interface is organized into a series of screens, each of which addresses a general area of the process of modeling a fire. General and key word help is always available except within the key word help section itself. The top of the screen shows which section is active. These names are shown below and are roughly descriptive of the area which is covered. These correspond to sections in the data file discussed in section 5. The bottom of the screen shows which special keys are active, or indicates what action is expected. If data can be entered, then the range and units will be shown if appropriate. For example, room width will be in units of length, whereas a title has no dimensions.

0	Initialization	only at the beginning
1	Overview	
2	Ambient Conditions	
3	Geometry	
4	Vents(doors...)	
5	Fans, Ducts,...	primary sections
6	Thermal Properties	
7	Fire Specification	
8	Calculations,...	
9	Results - temp,...	show results of calculation
10	Information and Settings	show the current version numbers and make permanent changes in the colors and units

Note that the Initialization screen (screen 0) and the output screens (screens 9-10) do not correspond to sections of the data file. Rather, they are used to retrieve and save the data file created with FAST_in. Refer to section 4.4 for the details of the data entered on each screen.

Overview	Title from section 4.4.1 Time specifications from section 4.4.1
Ambient Conditions	Ambient conditions from section 4.4.2
Geometry	Floor plan data from section 4.4.3
Vents(doors...)	Connections from section 4.4.4
Fans, Ducts,...	Mechanical ventilation from section 4.4.4
Thermal Properties	Thermophysical properties of enclosing surfaces from section 4.4.5
Fire Specification	Description of fire sources from section 4.4.6 Species production from section 4.4.7
Calculate,...	File specifications from section 4.4.8

In general, the program requests either data from the keyboard, or selection information from the function keys (or mouse if present). Any active function keys will be shown at the bottom of the screen. If the meaning is not clear, the **show keys** function key, f9, will give further explanation. Otherwise, there will be directions as to what further actions are possible. If alphanumeric input (data) is being requested, the entry must always be completed by pressing the enter key. For function keys, only a single keystroke is required. Some of the function keys are active throughout FAST_in; others are specific to certain screens. Those specific to individual screens are described in more detail on the following pages. Those active throughout the program are presented below.

key	key label	function
f1	go to page	Allows you to move directly from one screen to another within FAST_in. From any screen, pressing f1 brings up a menu listing all the screens in FAST_in. Using the mouse or the arrow keys, select the screen of interest and press enter or the left mouse button.
f2	return	Allows you to move directly from the current screen to the previous screen within FAST_in. As an example, if you are on the thermal properties screen and press Page Down to move to the thermal database screen, pressing f2 will return you to the thermal properties screen. Pressing f2 again will take you again to the thermal database screen. This switching may be continued as long as desired.
f3	help	You may press the HELP key, f3, at any time to receive context sensitive help describing the current screen or current quantity being entered. Pressing f3 a second time brings up a list of keywords for which more detailed help is available.
f8	change units	You may temporarily change the working engineering units displayed by FAST_in and used for data entry at any time by pressing f8 and selecting the quantity to be changed with the up and down arrow keys. Pressing the right or left arrow keys changes the working units of the currently selected

quantity. To change the units permanently, you must modify the installation parameters.

f9   show keys   provides a brief description of the function keys currently active and can be used to provide a quick reference of the current function of each of the keys.

f10   quit   is used to end the program.

```
FAST V 18.5    Initialization                              04/03/91


                  FILE: DATA.DAT
















|file|    |help|   | 1R | 3R |   |    |keys|quit|  input=>
```

On the Initialization screen, the FAST input file to be edited with FAST_in is selected. The name of any DOS file may be entered by typing in the name of the file or the user may press the select file key, f1, to see a list of files in the current working directory. By default, all files with an extension of .DAT are presented in the list. If desired, one may type a file matching pattern (such as *.* to see all files in the subdirectory) before pressing f1.

In addition to showing the name of the current screen, "Initialization" in this case, the name of the module, its version number and the current date are shown. The latter two can change, as the program is enhanced, and when run on dates different than shown in the figure.

If a completely new data file is to be created, two generic data sets are built into the program. Key f5 may be pressed to use a single room case and key f6 may be pressed to use a three room case.

```
┌─────────────────────────────────────────────────────────────────────┐
│ FAST V 18.5   Overview                                    04/03/91    │
│                                                                       │
│ File: DATA.DAT      Title:      demo #1 a single compartment          │
│                                                                       │
│ Geometry                  Time          Ambient Conditions  (external)│
│                                                                       │
│ Compartments      1  Simulation   180   Temperature    26.9     26.9  │
│     Vents...      1     Print      0       Pressure 1.0E+05   1.0E+05 │
│ MV connects       0     Dump       5     Station elv.    0.0      0.0 │
│                      Display       5       Wind speed             0.0 │
│                      Restart       0      Ref. height           10.0  │
│                                            Power law          0.1600  │
│ Fire Specification                                                    │
│                                                                       │
│             Type Specified fire(constrained)                         │
│      Species tracked    O2  CO2   CO TUHC  H2O    OD    CT            │
│                                                                       │
│                                                                       │
│                                                                       │
│                                                                       │
│                                                                       │
│ Range: Alphanumeric ( 50)   Units: Name or Title                     │
│ | go |    |help|  |    |    |   |unit|keys|quit|  input=> single compartment │
│                                                                       │
└─────────────────────────────────────────────────────────────────────┘
```

The Overview screen presents a summary of the FAST data file. The title, simulation time, print interval, dump interval, display interval, and restart time may be changed on the screen. All other information presented is changed on other screens of the program and is included here (in the "protected text" color) to provide a summary of the data set.

```
FAST V 18.5    Ambient conditions                                  04/03/91

              (internal)  (external)

Temperature    26.9         26.9
   Pressure  1.0E+05      1.0E+05
Station elv.    0.0          0.0

 Wind speed                  0.0
 Ref. height                10.0
  Power law               0.1600

Compartments     1      Maximum pressure differential    0.0
     Vents...    0           Maximum elevation change    2.30
 MV connects     0             Total internal volume     32.6




Range:     -73.1 to    76.9   Units: Temperature in CELSIUS
| go |    |help|    |    |    |    |unit|keys|quit|  input=>
```

On the Ambient Conditions screen, the internal and external ambient temperature, pressure, and station elevation along with information on external wind may be changed. The wind speed, scale height, and power law are used to calculate the wind coefficient for each vent connected to the outside. The wind velocity is specified at some reference height. The power law then provides a lapse rate for the wind speed. An assumption is that the wind velocity vanishes at the surface. The formula used to calculate the wind speed at the height of any vent is (wind speed) $\cdot$ ((vent height)/(scale height))$^{\text{(power law)}}$. The wind is applied to each external opening as a change in pressure outside of the vent. It is further modified by the wind coefficient used for the openings.

```
FAST V 18.5   Geometry                                          04/03/91

          Dimensions

Compartment Number:      1
              Width:    3.30
              Depth:    4.30
             Height:    2.30
    Floor elevation:     0.0












Range:      0.0 to    150.0   Units: Distance in METER
| go |     |help|ADD |DEL |   |    |unit|keys|quit|  input=>
```

On the Geometry screen, information on the sizes of all of the rooms are entered. The vent connections, entered on the Vents screen are shown here for reference only.

```
FAST V 18.5   Geometry                                          04/03/91

            Dimensions

  Compartment Number:        1
              Width:      3.30

    ┌─────────────────────────────────────────────────────┐
    │                                                      │
  Floor │Compartment #                              2      │
    │                                                      │
    │Width                                                 │
    │                                                      │
    │Depth (breadth)                                       │
    │                                                      │
    │Interior height                                       │
    │                                                      │
    │Height of floor above reference level                 │
    │(reference is specified in "Ambient")                 │
    │                                                      │
    └─────────────────────────────────────────────────────┘



  Range:      0.0 to     150.0   Units: Distance in METER
  <esc> to exit, <f2> accept data                    input=>
```

Rooms may be added to the simulation with the ADD key (f4) on the Geometry screen. Dimensions of the compartment, along with the height of the compartment floor above the reference height (specified on the Ambients screen) are entered in the overlaid window. The DELETE key (f5) may be used to delete a room.

```
FAST V 18.5   Vents(doors...)                              04/03/91

         Dimensions

Compartment Number:        1
            Width:      3.30
            Depth:      4.30
            Height:     2.30
 Floor elevation:       0.0

      Vents(doors...)

    with respect to first room     wrt second room    - absolute -
  #  width  sill  soffit  wind    #   sill  soffit   a_sil  a_sof Vent(1->4)
  1  1.07   0.0   2.0    0.0      2   0.0   2.0      0.0    2.0    1




Range:     0.0 to   4.30  Units: Distance in METER
| go |     |help|ADD |DEL |O/C |   |unit|keys|quit|  input=>
```

On the Vents screen, all of the connections betweens rooms and openings to the outside are specified. A vent may added or deleted using the ADD key (f4) or the DELETE key (f5). The OPEN/CLOSE key, f6, allows specification of the vent position over the course of the fire as detailed by the CVENT parameter in the FAST input file.

```
FAST V 18.5   Vents(doors...)                                    04/03/91

            Dimensions

Compartment Number:        1
              Width:     3.30

    Floor │First Compartment
          │
        V │Second Comparment
          │
     with │Vent number                              solute -
  #  widt │                                       l  a_sof Vent(1->4)
  1   1.0 │Width                                     2.0      1
          │
          │Soffit (with respect to first comp)
          │
          │Sill (with respect to first comp)


Range:       1 to       2  Units: Compartment number
<esc> to exit, <f2> accept data                    input=>
```

Like adding a room on the geometry screen, the ADD key, f4, may be used on the Vents screen. The vent is specified by the two connecting rooms and the size and location of the vent. A connection to the outside is defined by using a room number for the "Second Compartment" one greater than the total number of rooms entered on the Geometry screen.

```
FAST V 18.5   Fans, Ducts,...                                      04/03/91

                  Dimensions

Compartment Number:      1      2      3
            Width:     10.0   10.0   10.0
            Depth:     10.0   10.0   10.0
            Height:    5.00   5.00   5.00
Floor elevation:        0.0    0.0    0.0

              Fans, Ducts,...

Compartment      # node      Orientation     Height        Area

     1             1             V             4.50         1.00
     2             4             V             4.50         1.00
     1             5             V             4.50         1.00
     3             8             V             4.50         1.00




Range:        1 to      3  Units: Compartment number
| go |rtrn|help|ADD |DEL |DUCT|FAN |unit|keys|    |  input=>
```

Mechanical ventilation systems are entered on the Ducts screen. As detailed in section 4.4.4, this includes details of the connections from rooms to the ventilation system, and of the ductwork and fans in the system. These are specified on the three separate pages of the Ducts screen. On this first page, the connections between rooms and the ventilation system are detailed. These correspond to the MVOPN keyword in the FAST data file. Like the Geometry and Vents screens, these connections may be added or deleted with the ADD key (f4) or the delete key (f5). The DUCT key, f6, allows specification of the ductwork on the Fans, Ducts page. The FANS key, f7, allows specification of the operating characteristics of the fans in the system.

```
FAST V 18.5   Fans, Ducts,...                              04/03/91
                          Duct Work
        node                   abs       expanded        node
    1st   2nd   len    diam   rough   joint1 joint2   hght1  hght2
     1     2    5.00   0.15   0.0002    0.02   1.00    4.50   4.40
     3     4    5.00   0.15   0.0002    0.02   1.00    4.40   4.50
     5     6    5.00   0.15   0.0002    0.02   1.00    4.50   4.40
     7     8    5.00   0.15   0.0002    0.02   1.00    4.40   4.50




Range:      0.0 to   300.0   Units: Distance in METER
| go |rtm|help|ADD |DEL |    |   |unit|keys|    |  input=>
```

The ductwork in the ventilation system is specified on the Fans, Ducts page of the Ducts screen. These connections may be added or deleted with the ADD key (f4) or the delete key (f5). Pressing Page Up will return to the main Ducts screen.

```
FAST V 18.5   Fans, Ducts,...                                    04/03/91

                                  Duct Work
      node                          abs          expanded          node
   1st   2nd    len    diam       rough      joint1 joint2      hght1  hght2
    1     2     5.00   0.15      0.0002        0.02   1.00       4.50   4.40
    3    ┌─────────────────────────────────────────────┐       4.40   4.50
    5    │ Node 1 number                                │       4.50   4.40
    7    │ Node 2 number                                │       4.40   4.50
         │ Length                                       │
         │ Diameter                                     │
         │ Absolute Roughness                           │
         │ Flow Coefficent Node 1                       │
         │ Expanded Area of Joint Node 1                │
         │ Elevation Node 1                             │
         │ Flow Coefficent Node 2                       │
         │ Expanded Area of Joint Node 2                │
         │ Elevation Node 2                             │
         └─────────────────────────────────────────────┘




   Range:      1 to     100   Units: integer
   <esc> to exit, <f1> to accept the data              input=>
```

The ADD key on the Fans, Ducts page overlays a window to specify a connection between internal nodes of the mechanical ventilation system. All of the information for the MVDUCT and INELV keywords for the FAST data file, detailed in section 4.4.4 are entered for a single connection.

```
FAST V 18.5   Fans, Ducts,...                                    04/03/91

        Fan Setup     Number of Fans 2
    Fan # Node 1 Node 2  Pmin  :  Flow     Pmax  :  Flow  No Coeff
       1      6      7    0.00   0.1400    140.00   0.0405     5
       2      2      3    0.00   0.1400    140.00   0.0405     5



   Head    Flow   0.2000 +                                  Coefficent
    0.0    0.140         |                                   0.140E+00
   14.0    0.141         |                                   0.317E-03
   28.0    0.138         |   *   *   *   *                  -0.180E-04
   42.0    0.133         |                 *   *   *         0.190E-06
   56.0    0.127  0.1000 +                       *          -0.810E-09
   70.0    0.119         |                         *
   84.0    0.112         |                           *
   98.0    0.102         |                             *
  112.0    0.088         |
  126.0    0.069    0.0  +--------+--------+--------+--------+
  140.0    0.040         0.      35.      70.     105.     140.

Range:        1 to        2   Units: integer
| go |rtm|help|ADD |DEL |    |    |unit|keys|    |  input=>
```
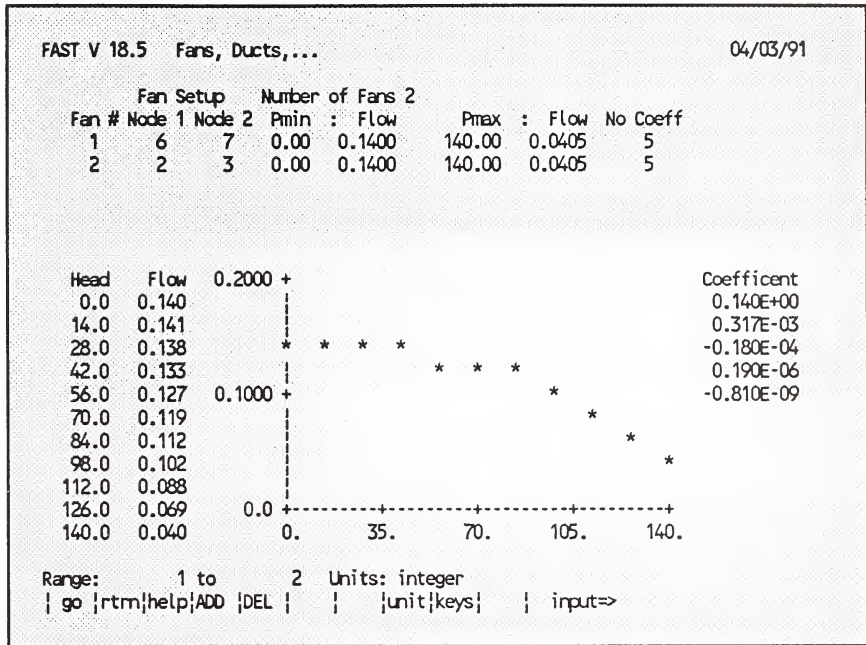
Operating characteristics of the fans in the ventilation system are specified on the Fan setup page. Fans may be added or deleted with the ADD key (f4) or the delete key (f5). Once a fan has been added to the system, the fan curve may be modified by either entering a set of pressure and flow data for a set of coefficients for the fan curve. In either case, the program will calculate the other quantity before leaving the Fan setup page. Pressing Page Up will return to the main Ducts screen.

```
┌─────────────────────────────────────────────────────────────────────────┐
│                                                                           │
│   FAST V 18.5    Thermal properties                             04/03/91  │
│                                                                           │
│   Compartment Number        1                                             │
│                                                                           │
│   Ceiling properties:      OFF                                            │
│      Floor properties:     OFF                                            │
│       Wall properties:     OFF                                            │
│                                                                           │
│                                                                           │
│                                                                           │
│                                                                           │
│                                                                           │
│                                                                           │
│                                                                           │
│                                                                           │
│                                                                           │
│                                                                           │
│                                                                           │
│                                                                           │
│   Range: Alphanumeric ( 8)     Units: Name or Title                       │
│   | go |    |help|ADD |DEL |DATA|    | |keys|quit|  input=>               │
│                                                                           │
└─────────────────────────────────────────────────────────────────────────┘
```

The Thermal Properties screen details the materials used for the ceilings, walls, and floors of all of the rooms as detailed in section 5.6. The name of a material contained in the FAST Thermal Database may be entered by first positioning the highlighted selection bar over the entry of interest and typing the material name exactly as it appears in the FAST thermal database. To make the process easier, a material name may be selected on the Thermal Database page below, and designated for the currently selected surface by pressing the ADD PICKED key, f4. To specify an adiabatic surface, press the DELETE key, f5, to turn OFF the heat transfer calculation for that surface. If the word NONE appears, it means that the name entered does not appear in the Thermal Database. The DATA key, f6, displays the thermal database.

```
FAST V 18.5    Thermal Database                                    04/03/91

          Conduct Specifi Density Thickne Emissiv      * CODES *
DFIR30M   0.180   900.0   790.0  0.016   0.900
PINEWOOD  0.120  2500.0   540.0  0.016   0.800
CONCRETE   1.75  1000.0  2200.0  0.150   0.940
REDOAK    0.150  1300.0   640.0  0.016   0.900
FIBERB    0.050  1250.0   240.0  0.016   0.900
WOOD      0.070  1000.0   250.0  0.016   0.980
DFIROM    0.130  1400.0   510.0  0.013   0.990
DFIR10M   0.150  1500.0   560.0  0.016   0.900
LIMEGLAS   1.40   760.0  2500.0  0.016   0.950
GLASFIBR  0.040   720.0    32.0  0.088   0.900
KAOWOOL   0.220  1047.0   128.0  0.116   0.970
GYPSUM    0.160   900.0   790.0  0.016   0.900
GYP1/2    0.160   900.0   790.0  0.013   0.900
GYP3/4    0.160   900.0   790.0  0.019   0.900
GYPX5/8   0.140   900.0   770.0  0.016   0.900
BRICK     0.180   900.0   790.0  0.076   0.900
GLASS      1.40   760.0  2500.0  0.006   0.100              U
FC1_L003  0.150  1500.0   790.0  0.016   0.900            I


Range:  0.010   to   90.0    Units: Conductivity in JOULE/SECOND/METER/KELVIN
  |   |   |help|ADD |DEL |PICK|     |unit|keys|     |  input=>
```

The contents of the FAST thermal database may be examined or changed on the Thermal Database screen. A new material may be added by pressing the ADD key, f4, or an existing one deleted by pressing the DELETE key, f5. A material can be chosen (and later added in the Thermal Properties screen) by positioning the highlighted selection bar over the material and pressing the PICK MATERIAL key, f6. The thermophysical data file can not be changed (saved after editing) by FAST_in, although it will shown as changed on the "save files" screen if changes have been made at this point.

Caution: If the database file contains data on layered assemblies, do not add materials to the file with the ADD key on this screen. This will result in the deletion of the middle and outer layers. Such files may be changed with the editor built into the shell.
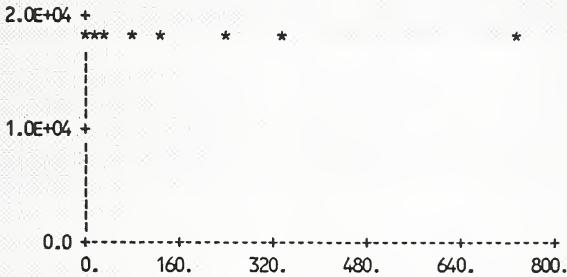
```
FAST V 18.5   Fire Specification                              04/03/91

        Heat of C   Lim O2    Rel Hum.   GMW      Pos    Room    Type
        1.8E+04      3.00        0.0     16.0       1      1       2


              2.0E+04 +
    ┌─────────────┐       *** *  *      *     *                    *
    │1  1.8E+04   │         |
    │2  1.8E+04   │         |
    │3  1.8E+04   │         |
    │4  1.8E+04   │         |
    │5  1.8E+04   │ 1.0E+04 +
    │6  1.8E+04   │         |
    │7  1.8E+04   │         |
    │8  1.8E+04   │         |
    └─────────────┘         |
                  0.0 +---------+---------+---------+---------+---------+
                      0.      160.      320.      480.      640.     800.


    Pyrolysis Heat_release  Height  Area  H/C CO/CO2 C/CO2 HCN HCL Ct

Range:    0.0010 to  6.0E+04   Units: Heat of Combustion in KILOJOULE/KILOGRAM
| go |       |help|ADD |DEL |MOD |     |unit|keys|quit|  input=>
```

All data pertaining to the combustion properties are entered on this screen. The heat of combustion, mass loss rate, and species yields created by MLTFUEL are entered, along with selection of the fire room and fire type as described in the data file format section. Note that fire chemistry is only allowed for constrained (type 2) fires.

A species may be added or deleted from the calculation using the ADD key (f4) or the DELETE key, f5. The time intervals may be modified by pressing the MODIFY TIME key, f6.

```
FAST V 18.5   Files,...                                          04/03/91



     quick estimates        <f5> asks for a time interval

     run time graphics      <f6> use existing display file (if it exists)

     save data file(s)      <f7>

     write to log file      <f8> no







  | go |   |help|   |   |   |   |   |   |   |quit|
```

Once data for a test case has been entered or modified using FAST_in, you may save the data to disk to run with the complete version of FAST. To save the data to a disk file, press f7. You may also append a simple graphics descriptor to the FAST data file by pressing f6. The resulting display will show selected variables in a simple X-Y plot on the screen as the model calculates the results. If problems are encountered with FAST_in, you can document the problem by generating a log file with the f8 function key and repeating the sequence of commands which generates the problem.

Once the software has been installed, you may change the display colors and engineering units used by HAZARD I for its displays and for interactive data input with FAST_in.

```
FAST V 18.5   Color Palette                                    04/03/91

  ▶MAIN HEADING

    SUB HEADING

    NORMAL TEXT
    PROTECTED TEXT
                              ┌─────────────────────┐
    MESSAGE OUTPUT            │This is a sample of the│
                             │help message text screen.│
    ERROR MESSAGE            │Usually it will have the │
                             │same background as that  │
    NORMAL BACKGROUND        │used for the messages and│
    MESSAGE BACKGROUND       │error codes.             │
    HELP BACKGROUND           └─────────────────────┘
    ERROR BACKGROUND



           │ │ │ │ │ │ │ │ │ │ │ │ │ │ │ │ │ │
           ↑                              ↑
```

You may change any or all of the colors used by HAZARD I and FAST_in for screen displays. Use the arrow keys up and down to select the type of display text to be changed and the right and left arrow keys to select the color for the foreground or background. The defaults have been selected to produce acceptable displays on both monochrome and color displays.

```
FAST V 18.5   Set Units                                              04/03/91

   Base Units     Current Units  Possible Units

   Temperature    CELSIUS        KELVIN      CELSIUS      RANKINE      FAHRENHEIT

   Pressure       PASCAL

   Length         METER

   Energy         KILOJOULE

   Mass           KILOGRAM

   Time           SECOND

   Time           SECOND


   ┌─────────────────────────────────────────────────────────────────────┐
   │To change units, highlight the basic unit to be changed, then point to the│
   │unit desired.  Pointing is done either with the cursor keys or the mouse. │
   └─────────────────────────────────────────────────────────────────────┘
```

As supplied, most of the engineering units used for interactive input and display by FAST_in are standard SI units. Energy defaults to kJ since rates of energy release are typically specified in kJ/s. Using the up and down arrow keys to select the unit to change and the left and right arrow keys to change the units.

4.6 FASTplot

The FAST model provides 3-D pictorial results and graphs while the model is executing. The model predicts the environment produced by a fire in one of several compartments, or rooms, and follows smoke and toxic gases from one compartment to another, separately predicting values for each of the variables in both the upper and lower layers. The results for "FAST" are written to a special data file (the "dump" file) after each prescribed time step. FASTplot is intended to provide a visual interface to generate graphs and tables from the time

histories saved by the model. FASTplot has the capability to form a list of variables, read in their values at each time interval, list the values in tabular form, plot the values, and save the variables in a formatted file for use with other software. In addition, it has the capability to read dump files created by other programs to plot along with FAST data.

To use FASTplot, select it from the shell or type the following command from the DOS prompt:

```
FASTPLOT <input> <,output > </N> </monitor type>
```

followed by an enter. All of the command line arguments and options are optional and are defined as

<input>
specifies the name of the DOS file or device from which the commands for FASTplot will be read. Normally (and by default if the argument is omitted) the keyboard will be used for input.

specifies the name of the DOS file or device which will receive the printed output and command prompts from FASTplot. Normally (and by default if the argument is omitted) the screen will be used for output.

</N>
including a /N on the command line will suppress the extended sign-on message issued by FASTplot.

</monitor type>
Fastplot can usually recognize the type of graphics monitor attached to your computer system automatically. If graphics output is garbled or not of the highest resolution possible for your system, you may include an option on the command line to force the graphics monitor to an appropriate type. The supported monitors are described in detail in section 4.5.

For the FAST dump files, the variables currently available are

boundary surface temperature (ceiling, floor)	WALL	C
entrained mass flow in the plume	ENTRAIN	kg/s
hcl wall surface concentration	HCL	kg/m^2
heat release in lower layer	LPLUME	kW
heat release in upper layer	UPLUME	kW
heat release in flame out a vent	VFIRE	kW
heat release rate of the fire	HEAT	kW
layer height	INTE	m
layer temperature	TEMP	C
layer mass density	MASS	kg/m^3
mass flow from the plume into the upper layer	PLUME	kg/s
pyrolysis rate of the fuel	PYROL	kg/s
pressure	PRES	Pa
radiation field to a target	TARGET	W/m^2
species density[2]	SPECIES	
total radiative heat flux into the layer	RAD	W
total convective heat flux into the layer	CONVEC	W
vent flow	VENT	kg/s
vent entrainment	JET	kg/s
volume of the upper layer	VOLUME	m^3

[2] For nitrogen, oxygen, carbon dioxide, fuel (tuhc) and water, the units are volume percent. For carbon monoxide and hydrogen cyanide, the units are parts per million. For optical depth the unit is inverse meters, and CT is dimensionless.

After identifying information, a "command prompt" appears and commands to direct the generation of the tables and graphs may be entered. Commands available at the "command prompt" are

ADD	LIST
ASCII	PLOT
AGAIN	RAPID
CLEAR	READ
DEFAULT	REVIEW
DELETE	SAVE
END	SHIFT
HELP	TENAB
FILE	VARIABLE

These commands can be broken into five major groups that describe the process used to generate tabular or graphical output with FASTplot. The following is a description of each of the commands. At least three characters must be used to identify a command.

4.6.1 Entering Data Into FASTplot

FASTplot can currently read three types of data files:

- data created by the FAST model (FAST dump files),

- data created by the TENAB model (TENAB dump files), and

- data created in specially formatted ASCII text files from other programs including RAPID, a program developed by CFR for analysis of large-scale fire tests.

Several commands are available within FASTplot to read these data files. They are FILE, AGAIN, and ADD (for FAST files), ASCII and RAPID (for ASCII

text files), and TENAB (for TENAB files). In addition, several commands provide ancillary functions to support data entry.

ADD   This command is used to build a list of FAST variables to be read into the active list. When an option is requested, ADD may be entered by itself or together with a list of variables that are to be added. If it is entered alone, there will be a request for the variables that are to be added to the list. For example:

> ADD
- INPUT VARIABLES TO BE ADDED >
       or
> ADD TEMP,PRES,......

For each variable selected there is a series of questions that will be asked to identify the type of that variable wanted. A question asked about all variables is:

WHICH COMPARTMENT? - >

For layer dependent variables, the user is asked to input the layer (U for upper or L for lower):

WHICH LAYER? - >

If VENTFLOW is chosen the compartment origin and destination will be requested as will the vent number; if SPECIES is selected the species name (O_2, CO_2,...) will be requested.

The maximum number of variables allowed in the active list at any one time is 20. If the list is full or the variable is presently in the active list the addition will be disallowed and another option requested.

ASCII   Read a file in columnar ASCII format. The next query will be
             for the columns to read. In order for this to work, there must be
             a column which corresponds to the default column as selected by
             the "DEFAULT" command. Normally this will be time, but can
             be any other column as desired.

FILE   The FILE command allows the user to specify the FAST dump
             file name for subsequent ADD commands. FILE applies only to
             FAST dump files.

RAPID   Read a file in the RAPID format. The next query will be for the
             channels to read. In order for this to work, there must be a
             channel which corresponds to the default channel as selected by
             the "DEFAULT" command. Normally this will be the time
             channel, but can be any other channel as desired.

TENAB   Read a file in the TENAB format. The TENAB program
             produces estimates for a number of tenability criteria for persons
             exposed to a fire environment predicted by the FAST model.
             The user must enter the "person number" and the desired criteria
             to be read from the file. The possibilities are:

             Tenab Variable List
             1.   Fractional Effective Dose Due to Gases - Bukowski
             2.   Fractional Effective Dose Due to Gases - Purser
             3.   Fractional Effective Dose Due to CO2 - Purser
             4.   Temperature - Deg C
             5.   Fractional Effective Dose Due to Convective Heat
             6.   CT (G-MIN/M3)
             7.   Flux (KW-MIN/M2)
             8.   Derksen Curve

The AGAIN, CLEAR, DELETE, READ, and REVIEW commands allow the user to view and manipulate the list of variables read with the data entry commands.

AGAIN   This will repeat the input of a list of variables for a new file. The program maintains a list of the most recently acquired FAST variables. First, get a file with "FILE," then get a set of variables. Once again using "FILE," get a new file and then use AGAIN to get the same list of variables on this new file. This function simplifies direct comparisons between runs of FAST.

CLEAR   This command empties the current variable list.

DELETE   When this option is entered the present list of variables will be printed to the screen and the user will be asked to input the variables to delete by the number associated with them on the list. They must be entered on a single line separated by commas or blanks. If the variable number that is input does not correspond to one that is currently on the list it will be skipped. After the deletions have been processed a new list is presented and another option requested. If the list is presently empty then that fact will be stated in an error message. One caution is in order. The variables are deleted by the number in the list, rather then by rank ordering within a group. This is important in conjunction with use of the AGAIN command.

READ   READ is used to force a read of the data files. This is most useful for script files which can be processed automatically to

display data. It is equivalent to pressing an enter at the "read prompt" in the interactive mode.

REVIEW   At times the user may wish to see what is presently on his list before entering a command. This may be done with the RE-VIEW command. It will print out the current list along with the compartment number, species, and layer of each of the variables. After the printing of the entire list, the option request is again displayed.

4.6.2 Generating Tables and Graphs With FASTplot

The commands LIST and PLOT allow the user to generate a table of values of selected variables or a graph of selected variables. The SHIFT command allows the user to shift the abscissa or ordinate axis of a variable.

LIST   List the values of any of the variables on the list to the screen. The variables to be listed and the time range of the list are entered. After the list appears on the screen, it can be printed with the PRINT SCREEN key.

PLOT   After entering the PLOT command, the current list of variables will be displayed along with their numbers. They should be entered in a string separated by commas or blank spaces. For example:

```
Select 1->4 graphs by grouping variables
with parentheses followed by a return >1,2,3,4
```

                                   or

```
Select 1->4 graphs by grouping variables
```

```
with parentheses followed by a return >1 2 3 4
```

Variables to be plotted together on a single graph are grouped in parentheses. For example:

```
Select 1->4 graphs by grouping variables
with parentheses followed by a return >(1 2 3 4)
```

Normally, the program will scale the axes automatically. However, if the automatic formatting option has been turned off, then before the graph is drawn, the user is given the opportunity to change the range of the X and Y axes and the graph legends. The maximum and minimum value of the X and Y axes will be displayed, followed by a request for a change in each, which will be of the form. If no change is desired simply enter an enter and the next axis change will be displayed:

```
The Min/Max for Temperature  are
X =      0.00 TO    2000.00
Y =      0.00 TO    1000.00

<ENTER> If no changes are desired.
     Xmin =       0.00, Change to =
     Xmax =    2000.00, Change to =
     Ymin =       0.00, Change to =
     Ymax =    1000.00, Change to =
```

Similar prompts are made for the legends for each graph. The user is allowed to change the text for each curve label and the position. If no changes are desired, the enter key may be pressed to accept the suggested values for the legend text and position:

```
Legend for  1 (Temperature  1 U  ) is ¦R 1 U¦. :
<ENTER> For no change:
Legend for  2 (Temperature  2 U  ) is ¦R 2 U¦. :
<ENTER> For no change:

Legend for graph 1 is at X=     40.00, Y=     945.49
<ENTER> If no changes are desired.
     X =      40.00, Change to =
```

Y =   945.49, Change to =

When all the changes have been made (if any) the graph of that particular variable will be plotted. After the graph has been completed the option request will be displayed and a new option may be entered.

SHIFT   SHIFT is used to adjust the variable axes. Typically, it is used only when plotting variables from different files to normalize the data to a common ignition time, initial temperature, or the like. The required input is a selection of the axis to shift, the amount of shift, and a list of channels. Please note that shifting the time axis for a single variable will shift the time axis for all variables associated with that particular file. Such an effect occurs because only one vector of values is kept for the time line for each file.

4.6.3 Printing Copies of FASTplot Graphs

A utility program called METAPRNT is provided with the HAZARD I software to allow you to print copies of the graphs on the screen on several dot-matrix printers. METAPRNT operates with most popular graphics adapter cards and can be used with the following printers: IBM Dot Matrix, IBM ProPrinter, Epson MX-80/100 or FX-80/100.

To use the screen copy facility, you must first execute the program METAPRNT *prior to starting HAZARD I* to install a resident driver. Subsequent presses of the SHIFT-PRTSC key will activate the METAPRNT utility to freeze the graphics screen and copy it to the dot matrix printer. To install the print utility, type the following command at the DOS prompt *prior to starting HAZARD I* :

METAPRNT <options>

The **<options>** allow you to control the output display format:

/R --   Rotate picture 90°
/I --   Inverse print
/F --   Form feed after printing
/2 --   Use printer attached to LPT2 instead of LPT1
/H --   Help
/K --   Kill. Removes METAPRNT from memory

For higher quality output, an output file compatible with Hewlett-Packard HPGL plotters can be generated and subsequently copied to the plotter. Section 4.6.5 provides details of specifying the HPGL output format.

4.6.4 Saving Data With FASTplot

The save command allows the user to create an ASCII text file in one of two formats. These files may be used for future FASTplot runs or for exporting FAST or TENAB data to other programs.

SAVE   A command to save the values of the variables in the list into a file. The format used will depend on the option chosen in "DEFAULT," columnar data for spreadsheet and charting programs, or row data for making the data directly compatible with our data processing program (RAPID) designed for the reduction of experimental data in the Center for Fire Research.

                The user will be asked for the name to be used for the file. A check will be made to see whether that file presently exists or not. If it does, the user will be asked if he wants to write over the old file with this new data. If his answer is NO, nothing will be placed in the file and other option requested. If, however, he

does want the file rewritten, or the file does not already exist, the new file will be created and the data stored in it.

Columnar data is straightforward, with each variable listed. The time channel will be the first column. For files in the row format, each variable in the list will be saved with the following line at the beginning of each block of data:

I6,I6,A6,*-----------COMMENT---------

The first I6 will be for the number of data points for that variable, the next I6 is for the number given to that variable on the list, and the A6 is the actual variable name. Everything after the * is a comment block and will be filled with information relevant to that particular variable, such as species number, compartment number, layer, etc. The actual numerical data will be written using the format 7E11.5.

4.6.5 Changing the Default Parameters in FASTplot

The default command allows the user to change a number of default parameters within FASTplot. These defaults specify the format of the graphical output and assumed values for some of the input parameters (ones where the user may simply press the enter key).

DEFAULT   This enables the user to set default parameters for the following:

Default compartment specifies the compartment number to be used whenever the user presses an enter in response to a question requesting a compartment number.   Ventflow destination specifies the compartment number for the "to compartment" for vent flows.   Default species and default layer specifies the species and layer to be used whenever the user presses an enter

in response to a question requesting a species or a layer, respectively. Character set is a number from 1 to 25 which specifies a different typeface to be used. Only character sets 4, 7, 24, and 25 are supplied with HAZARD I. Graphics device specifies where the graphic output will be placed. Allowable outputs are type 4 or SCREEN for output to the screen and type 6 or HPGL for output to a file formatted in format for Hewlett-Packard format devices. Automatic plot formatting allows the user to customize the format of the graphical output. A response of Yes tells the program to format the axes and legends automatically, or No to allow the user to select the axis limits and legend text manually for each plot. Channel for abscissa specifies the channel number to be used for the horizontal axis for data read from RAPID format data files with the RAPID command. Factor for abscissa specifies the number of the column of data to be used for the horizontal axis for data read in ASCII format. Type of save file specifies the format of the file written by the SAVE command. Finally, Draw curves in color (Y/N) and Draw curves with dashed lines (Y/N) allow the user to specify the lines to be drawn for each variable in a plot.

The defaults are saved in a permanent file on the disk so the next execution of FASTplot will use whatever defaults were most recently selected.

4.6.6 Getting Online Help in FASTplot

The HELP and VARIABLES command provides some simple online help for using FASTplot.

HELP   This command may be entered at any time that the user is asked for an option. Its purpose is to list to the screen, the available commands and a brief explanation, after which another option will be asked for.

VAR   Show the list of variables which are available. This list is identical to the one shown at the beginning of section 7.

4.6.7 Exiting FASTplot

The END command terminates the execution of FASTplot. IF desired, any data which has been read into FASTplot should be saved prior to entering this command. Any data not saved will be lost upon exiting the program and must be re-entered if it is to be used again.

4.7 FIREDATA

The material properties database for the Hazard Assessment Method was created using DbaseIII Plus. (DbaseIII Plus will hereafter be referred to simply as Dbase.) To facilitate the use of the data base, a set of procedures was written to enter, edit, and retrieve data for use as input to HAZARD I. The procedures were written to give the casual Dbase user access to the information contained within the databases as well as update them without understanding the databases, their structure, or their relationship to each other.

4.7.1 Database Structure

The material properties database is composed of five interlocked (not indexed) databases. This was done to reduce the search time for specific pieces of information. The five databases are:

- Material Directory   (MATDIR.DBF);
- Material Property   (PHYSICAL.DBF);
- Cone Calorimeter   (DECOMCC.DBF);
- Furniture Calorimeter   (DECOMFC.DBF);
- Toxicity   (TOXICITY.DBF).

The databases have two fields in common; the material code (Mcode) and the material identification or description (Mid). The databases, however, are not indexed. For special applications, this will allow one or several of the databases to be accessed by a user written retrieval program outside of the Dbase environment.

The material directory (MATDIR.DBF) contains information about the presence of data in the other four databases for a given material code or material description. For example, if toxicity data is necessary, the procedures will first check the material directory database to ascertain if the material of interest has been entered into the databases and, in particular, if data exists in the toxicity database. When data are entered into the databases, a record for each material code is added to the material directory indicating the material code, material description and four TRUE/FALSE fields showing where data has been placed in the other four databases.

The material property database (PHYSICAL.DBF) contains information on the thermophysical properties of a material. It is composed of a single input form that provides conductivity, specific heat, and emissivity values for a given material as a function of temperature. Up to six temperatures can be entered or retrieved. These values relate to a specific form and density of material. For other densities or forms, additional records must be entered. This database contains records relating to combustible and noncombustible materials which serve as interior finish (walls, floor, ceiling) or as furnishings. For example, the thermophysical properties of firebrick as well as carpeting will be found in the database.

Three databases exist that contain fire response or fire property data. Small-scale heat release and species yield data (grams of the species produced by each

```
                        Thermophysical Data

    Material Code: RDO001
    Material ID: RED OAK

    Form:              Volume Density:    640.00 kg/m3
                       Areal Density:     0.000 kg/m2
    Temperature        Conductivity       Specific Heat     Emissivity
       (C)             (kW/(m·K))         (kJ/(kg·K))
       20.0            0.000150           1.3000            0.900
      100.0            0.000190           1.8200            0.900
        0.0            0.000000           0.0000            0.000
        0.0            0.000000           0.0000            0.000
        0.0            0.000000           0.0000            0.000
        0.0            0.000000           0.0000            0.000
```

gram of fuel lost) are contained in the Cone Calorimeter database (DECOMCC.DBF), while medium- and large-scale heat release and species yield data are contained in the Furniture Calorimeter database (DECOMFC.DBF). Toxic potency data can be found in the toxicity database (TOXICITY.DBF).

The Cone Calorimeter database (DECOMCC.DBF) consists of a two screen form. The first screen contains basic information about the test sample and exposure conditions (i.e., initial and final sample weight, orientation, ignition mode, incident energy, time to ignition). A summary of the test results, where available, can also be found on this screen. This is presented in the form of average and maximum values and the time for the maximum value (from either ignition or start of exposure for non-flaming exposures). The second screen contains time dependent data for heat release rate, mass loss rate, CO yield, and CO_2 yield. Two additional time dependent fields are provided for user defined yields of other combustion products (e.g., soot, HCN).

The Furniture Calorimeter database (DECOMFC.DBF) is similar to the Cone Calorimeter database. It is also divided into two screens (see page 229). The

first presents test sample and exposure information as well as average and maximum values. The second screen represents time dependent information for the same properties as described for the second screen of the Cone Calorimeter database. Data from furniture items tested in large-scale compartments are also included in this database.

```
                    Decomposition Data from Cone Calorimeter

   Material Code: RDO002
   Material ID: RED OAK,7/8 IN.THICK  (1468)
   Form: BOARD


   Orientation(V/H):  V   Ignition Mode(P/N): P  Incident Energy: 100.00 Kw/m2
   Initial Mass:  162.300 g   Final Mass:   27.300
   Ignition Time:    9.0 s

                          Units      Average
   Heat of Combustion    Kj/Kg      14980.0
   CO    Yield           Kg/Kg       0.0008
   CO2   Yield           Kg/Kg       0.0048
   HC    Yield           Kg/Kg       0.0011
   HCl   Yield           Kg/Kg       0.0000
   HCN   Yield           Kg/Kg       0.0000
   H2O   Yield           Kg/Kg       0.6403
   SOOT  Yield           Kg/Kg       0.0054
   Extinction Area       m2/Kg       32.970
   Press any key to continue...
```

```
                              Time Dependent Data
           Heat        Mass        CO          CO2
  Time    Release      Loss       Yield       Yield      Yield      Yield
   (s)    (Kw/m2)     (Kg/s)     (Kg/Kg)     (Kg/Kg)    (Kg/Kg)    (Kg/Kg)
   0.0      0.00     0.000000     0.000       0.000      0.000      0.000
  10.0    150.00     0.000230     0.000       0.232      0.000      0.000
  20.0    375.00     0.000220     0.000       0.113      0.000      0.000
  30.0    348.00     0.000200     0.001       0.000      0.000      0.000
  40.0    309.00     0.000190     0.001       0.000      0.000      0.000
  60.0    256.00     0.000170     0.001       0.000      0.000      0.000
 120.0    220.00     0.000150     0.001       0.000      0.000      0.000
 360.0    185.00     0.000140     0.000       0.000      0.000      0.000
 720.0    281.00     0.000190     0.000       0.000      0.000      0.000
1080.0     57.00     0.000010     0.026       0.000      0.000      0.000
Enter P)rinter or E)xit:
```

```
              Decomposition Data from Furniture Calorimeter

     Material Code: UPC001
     Material ID: UPHOLSTERED CHAIR,F21,WOOD FRAME,PU FOAM-FR,OLEFIN
     Configuration:CENTER
     Ignition Source: GAS BURNER,50KW,200S


     Initial Mass:   28.300 kg   Final Mass:   0.000 kg
     Ignition Time:    0.0 s

                        Units      Average
     Heat of Combustion  kJ/kg     18100.0
     CO   Yield          kg/kg      0.0000
     CO2  Yield          kg/kg      0.0000
     HC   Yield          kg/kg      0.0000
     HCl  Yield          kg/kg      0.0000
     HCN  Yield          kg/kg      0.0000
     H2O  Yield          kg/kg      0.0000
     SOOT Yield          kg/kg      0.0000
     Extinction Area     m2/kg      0.000
     Press any key to continue...
```

```
                              Time Dependent Data
              Heat      Mass        CO        CO2       SMOKE
    Time    Release    Loss       Yield      Yield      Yield      Yield
    (s)      (kW)      (kg/s)     (kg/kg)    (kg/kg)    (kg/kg)    (kg/kg)
     0.0      0.00    0.000000    0.000      0.000      0.000      0.000
    60.0      0.00    0.000000    0.000      0.000      0.000      0.000
   150.0     90.00    0.005000    0.030      0.670      0.008      0.000
   200.0    450.00    0.025000    0.024      0.760      0.015      0.000
   260.0   2100.00    0.116000    0.016      1.070      0.020      0.000
   325.0    600.00    0.033000    0.000      0.710      0.022      0.000
   450.0    150.00    0.008000    0.016      0.590      0.001      0.000
   600.0    150.00    0.008000    0.000      0.540      0.000      0.000
   900.0     90.00    0.005000    0.000      0.750      0.000      0.000
  2000.0      0.00    0.000000    0.000      0.000      0.000      0.000
  Enter P)rinter or E)xit:
```

The toxicity database (TOXICITY.DBF) is composed of two screens of LC_{50} data (see page 231). The first screen, provides data from the cup furnace toxicity screening protocol (NBS), while the second, provides data on material tests performed according to the University of Pittsburgh Protocol. For the NBS Toxicity Protocol, auto-ignition temperatures are listed. Provisions for several different LC_{50} endpoint times are made. This is intended to accommodate the input of pure gas data as well as possible future alterations in the protocol. The University of Pittsburgh screen also allows for variations in data reported by small alterations in the protocol. Here provisions are made for different heating rates of the sample and different endpoint times for the determination of LC_{50} values (in grams).

Toxicity Data

National Bureau of Standards Protocol

Material Code: RD0003
Material ID: RED OAK FLOORING

Form: BOARD

Auto-Ignition Temperature: 480 C
Material at LC50

Time (m)	Flaming (mg/l)	Non-Flaming (mg/l)
30	56.800	30.300
0	0.000	0.000
0	0.000	0.000
0	0.000	0.000
0	0.000	0.000
0	0.000	0.000

Press any key to continue...

University of Pittsburgh Protocol
Material Loading at LC50

Heating Rate (C/min)	10min-post (g)	14days-post (g)
0.0	0.000	0.000
0.0	0.000	0.000
0.0	0.000	0.000

Enter P)rinter or E)xit:

4.7.2 Program Structure

FIREDATA is a program that operates as a DOS program. It is actually the main program of a series of subprograms that give the user the capabilities to add, edit, and retrieve data from a collection of databases with only a casual familiarity with Dbase. There are two levels to FIREDATA. The first level is FIREDATA.PRG. At this level the user is able to move to the second command level by selecting a specific operation (i.e., appending, editing, searching).

The group of subprograms are dedicated to perform a specific operation on a specific database. There are four programs for adding data, one for each database, and four programs for editing data, one for each database. Associated with each database, there is a format file that contains the input form that is used to enter data into each database. These format files are shared by the ADD and EDIT options. They have files names of TOXFORM.FMT, CONFORM.FMT, FURNFORM.FMT, and PHYFORM.FMT.

Data can be recalled in one of two ways. One approach is to search for a specific data record. The other approach is to list blocks of data records. The FIND and LIST options implement these two approaches. Both options share the same print programs. These appear as TOXFMT.PRG, CONEFMT.PRG, PHYFMT.PRG, or FURNFMT.PRG.

Figure 9 is an overview of the FIREDATA program structure showing the relationship between the various parts. As can be seen, it is not possible to move between second level commands without first returning to the first level commands. This is done to ensure that databases are properly closed before moving on to the next operation.
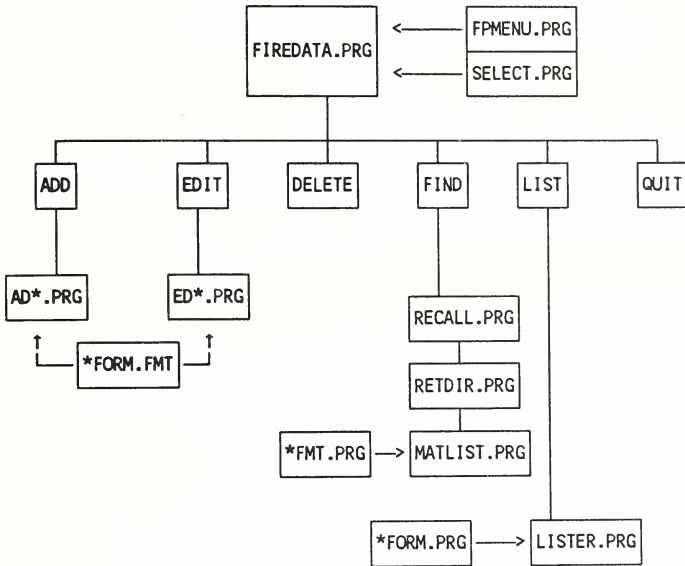
Figure 9. FIREDATA program structure.

4.7.3 Starting FIREDATA

FIREDATA is started by selecting it from the shell or by typing

    FIREDATA

and pressing enter at the DOS prompt.

A main menu screen is presented to the user that requests a character be entered from the list of six possible choices:

```
A)dd       E)dit      D)elete
     F)ind      L)ist
              Q)uit
```

followed by pressing enter. Any other entry will be ignored. If the user selects Q, the program will close all files, reset screen parameters, and end FIREDATA returning to the shell or to DOS.

4.7.4 Adding Data

If the user selects A, a secondary menu is placed on the screen. This menu requires that the user select the database to which the data will be appended. There are six selections at this point as well.

```
M)aterial property    C)one calorimeter
T)oxicity             F)urniture calorimeter
A)ll                  E)xit
```

If the user selects E, the program returns to the previous menu. If the user selects A, the program will sequentially request information for each database beginning with material property (i.e., thermophysical properties), Cone Calorimeter, Furniture Calorimeter, and, finally, toxicity. Any other selection, moves the user directly to entering data for that particular database.

The selection of a particular database for data addition results in one of four forms being presented to the user. Each form is to be completed by the user in as complete a fashion as possible. Errors on a given field can be corrected by backspacing and typing over the incorrect information. If one has left the field, the cursor control keys (i.e., arrow keys) can be used to return to a previous field and type over the error. On a multi-screen form, either screen can be reviewed by using the "Page Down" key to move forward or the "Page Up" key to move backward. At the completion of each form, the user is required to

depress the "End" key while holding down the "Ctrl" key. This ensures that the data are properly appended to the database. The program prompts the user to determine if another record will be appended to the same database.

"Do you want to exit this operation?(Y/N)"

If the user responds "Y", then the program returns to the previous menu. If the user responds "N", then the program presents the user with a blank form. This enables the user to append information to a given database on several materials without returning to the selection menu.

For the A)ll option, the user is presented with the database form for the appropriate database entry for material property data, Cone Calorimeter data, Furniture Calorimeter data, and toxicity data. As each screen of a multi-screen form is completed, the program automatically presents the user with the second screen. Prior to completing the second screen the user may use the cursor control keys (i.e., arrow keys) to move about each screen and move from screen to screen with the "Page Up" and "Page Down" keys. The "Enter" key may be used to leave every field except the last field on the entire form. (That is, for multi-screen forms the last entry on the last screen.) It is preferable to use the cursor keys to leave each field. *In order to actually append the data to the end of a database, the user must depress the "End" key while holding down the "Ctrl" key. Once data has been appended to a database, changes in a field must be accomplished by using the Edit option in the main menu.*

4.7.5 Editing Data

If the user selects E, a secondary menu is displayed on the screen. This secondary menu is identical to that used in adding data to a database.

```
M)aterial property    C)one calorimeter
T)oxicity             F)urniture calorimeter
A)ll                  E)xit
```

However, the A)ll option is not functional under this selection choice. If the user selects E, the program returns to the previous menu. Upon selecting a database, the program requests that you

"Enter MATERIAL CODE of record to be edited:".

This is the Mcode previously discussed. For the selected database, the program searches for a match between the Mcode entered by the user and the Mcodes stored in the database. If a match is not found, the program informs the user of that fact. The program responds in one of two ways. It either says

"Not found in {name of} database"

or

"NO data in {name of} database",

where {name of} is the name of one of the four databases. The first response indicates that the database may have been corrupted. This problem may be beyond the capabilities of the casual user to correct, because it indicates that the data should be present in the database but is not. *(The only protection from a corrupted database is to keep regular back-up copies of the files and go back to the last good copy if a corruption occurs.)* The second response simply means that the data has never been entered for this Mcode into this particular database.

If a match is found, the program presents the information in the selected record using the original screen forms. Corrections and additions on a given field can be accomplished by using the arrow keys to position the cursor in the desired field and type over existing data or type in missing data. Corrections within a field are done by backspacing and typing over the incorrect information. If one has left the field, the cursor control keys can be used to return to the offending field and type over the error. On a multi-screen form, either screen can be reviewed by using the Page Down key to move forward or the Page Up key to move backward. At the completion of each form, the user is required to depress the "End" key while holding down the "Ctrl" key. This ensures that the data are properly replaced in the database. The program prompts the user to determine if another record with the same Mcode and database will be edited. A response of "N" to the question,

```
"Search for next record?(Y/N)"
```

will return the program to the secondary menu, while a response of "Y" will continue searching the database for additional records with matching Mcodes. If any are found the appropriate screen forms are used and the user is permitted to alter the data in these records as well.

4.7.6 Retrieving Data

Data can be retrieved from specific databases in two ways. Specific records can be found and displayed or groups of records can be automatically found and displayed. In either case the data can be displayed on the screen or printed on a printer. The output format is similar to the forms used for entering data.

If the user selects F, the program clears the screen and presents a short description of the procedure used for finding and displaying a specific record. Data are retrieved from the various databases by an interactive procedure that utilizes the user's requirements to define the specific record of interest. Since the exact name of a material may not be known or may be ambiguously entered into the databases, the program requests that the user enter a key word(s) {At

this point, the user can enter the word EXIT to return to the main menu screen.} and select the database to be searched. For example, gypsum, an acceptable key word, can modify many words such as gypsum wallboard or gypsum walls. Another example would be polyurethane which could be entered as polyurethane foam seat cushions or polyurethane foam insulation. This information is used to display MATERIAL CODE and MATERIAL IDENTIFICATION fields containing the specified key word(s) for the selected database. Then, the user is required to enter the MATERIAL CODE (letters must be all caps.) so that a listing of records with the selected MATERIAL CODE can be displayed. This latter display presents the information contained in each record as it was entered into the database. The user can print each screen of information to a printer for later use.

If the user selects L, he will be presented with a short description of the listing process. This option has been implemented to provide the user with a rapid means for determining the contents of the various databases composing FIREDATA. [A word of warning. This procedure does not search each database but instead searches the master directory. The programs provided automatically update the master directory when new entries are made to a file. If other means are used to add data, this will not be the case.] The listing procedure provides the user with the material code and material identification fields in addition to showing which of the four databases contain entries for the listed materials. The listing can be performed based on record numbers or material codes. One leaves the listing program by selecting the E)xit option. This returns the user to the main menu.

The listing by record number requires that the user provide the numbers of the first record to be printed and of the last record to be printed. If the user leaves out the number of the first record, the system assumes that the first record in the database is intended. Similarly, for the last record to be printed, the system assumes that if one is not entered the listing process continues to the end of the file. If a printer is connected to the system, the listing process can be directed to the printer instead of the screen.

Listing by material codes is primarily intended for the development of tables of materials. It functions in an analogous manner as the listing by record numbers. The absence of an entry implies that the listing is to proceed to the extremes of the database.

4.8 MLTFUEL

The fire model FAST requires that the fire be input as a single heat of combustion, plus a time series of mass loss rates and yields of the species of interest. When there are multiple items burning simultaneously, this input requires that a composite of all of the items be used, where each separate burning item will generally have a different set of values for each of these parameters. The purpose of the program MLTFUEL is to convert these values for each burning item into the required composite fire. To start the program, select the module from the shell or type

MLTFUEL

and press enter at the DOS prompt. While the units of the results will be the same as the units input (everything is multiplied by dimensionless parameters), it is suggested that SI units be used to avoid confusion later.

Like FAST_in, MLTFUEL is a user-friendly and highly interactive module and is best mastered by following the example presented in chapter 3. For other fire simulations, the process is similar to that presented in the example and follows several steps.

For each item which burns simultaneously:

1) Enter the name of the item and heat of combustion
2) Enter the times, mass loss rates, and species yields for the item acquired from FIREDATA or from other sources.

Once all of the data for the items have been entered

3)   a combined timeline, effective mass loss rates, and effective species yields are calculated for the composite fuel.

4)   The data calculated above is printed for later manual entry into the fire specification in FAST_in.

At any point in the process, the data for any entry can be modified or deleted. Additional items can be added or deleted and the composite fuel results viewed as desired until the fire specification appropriate for a given scenario is obtained.

The program assumes that the burning characteristics of multiple items burning together are the same as those measured for each item burning individually - that is, that there are no interactions. This is obviously not the case. Each item will be affected by the radiation and convection from the others, increasing the burning (mass loss) rates; thus making this assumption nonconservative. These interactions are, however, beyond the scope of the present model, but will be included in future versions. For the present, the user should keep this limitation in mind and may choose to make an arbitrary adjustment in mass loss rates as a safety factor.

4.9 TENAB

TENAB is a FORTRAN program which follows a person's escape route through a building containing a fire as determined by the program EXITT (version 18), and for each occupant, accumulates fractional effective doses due to gases, FED (a variation of FED used in Hazard I), FEDP (Purser) and FEDCO2, the exposure to radiant energy which might cause burns on exposed skin (FLUX), the integrated concentration-time product (CT), and exposure to convective heat (TEMPA and FEDTEMP) from the data generated by FAST (version 18) in terms of their estimated effect on that person along his escape route. The program is interactive and requires a minimum of four pieces of information. To start the program, select the module from the shell or type

and press enter at the DOS prompt.

4.9.1 Input from FAST

TENAB requires a "dump" file from a FAST run. Upon executing TENAB, the user will be prompted for the name of the dump file. If a file name corresponding to a nonexistent file is input, the user will be informed that no such file exists and will be prompted for another file name. After entering a valid file name, the user will again be prompted for a Fast dump file. If additional Fast dump files are to be used (as in the case the FAST restart facility is used) the user enters them one at a time. When there are no more Fast dump file names to enter, the user should press the return key. If, for some reason, the user wants to abort the run, a / may be entered instead of a file name.

4.9.2 Input from EXITT

TENAB requires input from an EXITT run corresponding to the FAST dump file. The data may be entered from the terminal, in which case TENAB prompts the user for the necessary information, or the data may be read from a disk file created by the user or the EXITT program.

After being prompted for the FAST file name, the user will be prompted for the name of the EXITT output file. If the user wishes to enter the data at the terminal the user should enter the device name corresponding to the keyboard/terminal (CON on the PC). If a file name corresponding to a nonexistent file is entered, the user will be informed that no such file exists and will then be prompted for another file name. If it is then desired to halt TENAB, the user may enter a / for a file name, which aborts the run and returns to the system.

4.9.3 Format for an EXITT Data File

The EXITT data file consists of four sections of which three are required and one is optional. The first section, which is required, is a single entry consisting of the number of nodes in the floor plan (a node refers to a location in the building (a room or a point in a room), a door or a window) upon which the EXITT run was made. The second section, which is also required, consists of the data corresponding to the escape routes taken by the occupants. The third section, which is required, consists of the mapping between the "FAST" rooms and the "EXITT" nodes. (Since FAST is limited to at most six rooms on the PC, some nodes for EXITT may refer to the same room for FAST.) The fourth and last section, which is optional, contains data on the threshold values for incapacitation due to FED, FEDP (Purser), FEDCO2, FEDTEMP, TEMPA, and CT. If this section is omitted, default values will be used.

The format for the EXITT data file is as follows:

The first section is just a single integer denoting the total number of nodes, NR, in the floor plan.

The second section, describing the escape routes taken by the occupants, is entered as ordered-integer quadruplets as follows:

Occupant No., Node No., Time arrived at node, Height

where

*   Occupant No. must be a positive integer,

*   Node No. must be a positive number between 1 and the number of nodes in the building,

*   Time arrived must be non-negative and in seconds.

- Height entered is the distance in meters the occupant is from the base floor (when a room has a loft or balcony). It is a non-negative floating point number (usually 0.0).

The maximum number of nodes visited by an occupant is 100. A zero entry for time denotes the location of the occupant at the start of the simulation.

The third section consists of NR integers, separated by commas or spaces, which lie between 1 and 2 + the number of rooms with which FAST was run (NF). The row(s) would appear as follows:

$N_1,N_2,N_3,...,N_{NR}$ where: N_i represents to which FAST room the i-th room of EXITT corresponds. Note FAST room NF + 1 refers to the outside via a door and NF + 2 refers to a window.

The last section of the file (optional) indicates whether the user wants to specify his own critical levels for incapacitation due to FED, TEMPA (in °C), CT (in g-min/m^2), FEDP, FEDTEMP, and FEDCO2 and for lethality due to FED, TEMPA, and CT. The critical levels for incapacitation and lethality are entered in the order given above. An entry of -1. indicates that the user wishes to use the default value. The default values for incapacitation are .5, 65., 450., 1., 1., 1. and for lethality, 1., 100., 900.

In order for TENAB to know if the optional section is present one of the following rows of data must immediately follow the second section.

1.   The fourth section is not present.
      0,0,0,0.

or

2.   The fourth section is present.
      -1,0,0,0.

A commented sample data file is shown below (EXITT assumes six rooms and FAST assumes five rooms):

6	(EXITT run with a floor plan of six rooms)
1,1,0,0.	(person 1 in room 1 at time 0 s on base floor level)
2,2,0,0.	(person 2 in room 2 at time 0 s on base floor level)
1,2,120,0.	(person 1 in room 2 at time 120 s on base floor level)
1,3,600,0.	(person 1 in room 3 at time 600 s on base floor level)
1,6,500,0.	(person 1 in room 6 at time 500 s on base floor level)
2,3,720,0.	(person 2 in room 3 at time 720 s on base floor level)
-1,0,0,0.	(indicates the fourth section is present)
1,2,2,3,4,5	(indicates room 1 of EXITT corresponds to room 1 of FAST, room 2 of EXITT corresponds to room 2 of FAST, room 3 of EXITT corresponds to room 2 of FAST, room 4 of EXITT corresponds to room 3 of FAST, room 5 of EXITT corresponds to room 4 of FAST, room 6 of EXITT corresponds to room 5 of FAST)
-1.,-1.,400.,-1.,-1.,-1	(default for $FED(CO_2,CO,HCN,O_2)$, TEMPERATURE, $FED(CO_2,CO,HCN,O_2$, Purser's equations), FED(convective heat), and $FED(CO_2)$ and 400. for Ct incapacitation)
-1.,-1.,800.	(default for $FED(CO_2,CO,HCN,O_2)$, TEMPERATURE, and 800. for Ct for lethality)

4.9.4 Entering EXITT Data from the Terminal

To enter the EXITT data from the terminal when running TENAB the user needs to respond to the prompts. When prompted for the number of nodes, the user keys in an integer value denoting the total number of nodes in the floor plan upon which the escape routes are determined and hits the return key.

When prompted for the Occupant No., Node No., Time Entered and Height, the user keys in the data as follows

Occupant No.,Node No.,Time (seconds),Height

Entries are separated by spaces and/or commas and the line is ended with a return.

The occupant number must be a positive integer. The node number must be an integer between 1 and the number of nodes in the building. The time must be a non-negative integer in seconds. The height from base floor level (as occurs when there is a room with a loft or balcony) is a non-negative floating point number (usually 0.0).

To end the input of occupant information, the user simply presses the enter key.

After the occupant and the room information are entered, the current incapacitation and lethality critical values will appear on the screen and the user may opt to change any of the values appearing on the screen. This is done by selecting the appropriate option number (each measure is associated with a unique option number) and entering the new value. When no more changes are desired the user simply presses the enter key.

4.9.5 Output from TENAB

After the user is prompted for the input FAST and EXITT file names, the user is prompted for the name to be given to the output file. The user may have the output written to disk by entering a valid file name or he may have the output routed directly to the printer by entering the printer device name (PRN on the PC), or to the screen by entering the screen device name (CON on the PC). In the case the file already exists the user will be allowed to overwrite the file (provided it is not a file already in use by TENAB) or to enter a different file name.

The output from TENAB begins by listing the FAST and EXITT file names used. Then TENAB writes out the EXITT data and the incapacitation critical levels for FED, TEMPA, CT, FEDP, FEDTEMP, and FEDCO2 and the lethality critical levels for FED, TEMPA and CT.

The last part of the output is in tabular form. For each person, TENAB outputs in time order the pertinent information corresponding to when a person's FED, TEMPA, CT, FLUX, FEDP, FEDTEMP, or FEDCO2 exceeds a critical level or when a person is able to exit the building or arrives at a window. The pertinent information consists of the time of the occurrence, the node number (according to EXITT) of occurrence, the condition of the person (dead or incapacitated) due to the occurrence, the factor cause, and the values of FED, TEMPA, CT, FLUX, FEDP, FEDTEMP, and FEDCO2 at that time. Information related to the final time (the occupant's condition at the end of the simulation) is also recorded. A sample of the output is shown on the next page.

FAST Version: 18.3
TENAB Version: 18.0 - Creation Date: 10/31/88 - Run Date: 11/01/88

INPUT FAST FILE : SHAR6.DMP
INPUT EXITT FILE : C:
TENABS OUTPUT FILE: SHAR6.TEN

OCCUPANT	ROOM NUMBER	NODE NUMBER	FLOOR ELEVATION	ENTER TIME (S)
1	1	1	0.	0.
	3	3	0.	60.
	5	5	0.	120.
2	2	2	0.	0.
	4	4	0.	180.

FACTORS	INCAPACITATION LEVEL	LETHAL LEVEL
FED1	0.5	1.0
TEMP1 DEG C	65.0	100.0
CT (G-MIN/M3)	450.0	900.0
FED2	1.0	
TEMP2	1.0	
FED3	1.0	

PERSON 1

TIME	ROOM	CONDITION	CAUSE	FED1 FED2 FED3	TEMP1 TEMP2	CT	FLUX
(SEC)						(G-MIN/M3)	(KW-MIN/M2)
160.	5	INCAPACITATED	TEMP1	0.219E-02 0.105E-02 0.586E-02	0.729E+02 0.378E-01	0.000E+00	0.112E+00
190.	5	DEAD	TEMP1	0.307E-02 0.125E-02 0.686E-02	0.108E+03 0.590E-01	0.000E+00	0.113E+00
310.	5	INCAPACITATED	TEMP2	0.314E-01 0.415E-01 0.889E-01	0.145E+03 0.101E+01	0.000E+00	0.151E+00
450.	5	INCAPACITATED	FED2	0.128E+00 0.102E+01 0.635E+00	0.666E+02 0.130E+01	0.000E+00	0.157E+00
600.	5	FINAL TIME		0.176E+00 0.187E+01 0.913E+00	0.601E+02 0.135E+01	0.000E+00	0.157E+00

PERSON 2

TIME	ROOM	CONDITION	CAUSE	FED1 FED2 FED3	TEMP1 TEMP2	CT	FLUX
(SEC)						(G-MIN/M3)	(KW-MIN/M2)
310.	4	INCAPACITATED	TEMP1	0.997E-02 0.429E+00 0.940E-01	0.204E+03 0.351E+00	0.000E+00	0.368E+01
310.	4	DEAD	TEMP1	0.997E-02 0.429E+00 0.940E-01	0.204E+03 0.351E+00	0.000E+00	0.368E+01
320.	4	INCAPACITATED	FED2	0.247E-01 0.159E+01 0.254E+00	0.164E+03 0.593E+00	0.000E+00	0.369E+01
450.	4	INCAPACITATED	TEMP2	0.103E+00 0.632E+01 0.896E+00	0.104E+03 0.101E+01	0.000E+00	0.371E+01
460.	4	INCAPACITATED	FED3	0.123E+00 0.728E+01 0.102E+01	0.988E+02 0.106E+01	0.000E+00	0.371E+01
600.	4	FINAL TIME		0.185E+00 0.101E+02 0.131E+01	0.922E+02 0.120E+01	0.000E+00	0.371E+01

FED1 - THE FRACTIONAL EFFECTIVE DOSE DUE TO
        CO,CO2,HCN AND O2 BASED ON THE HAZARD I
        TENAB FED PLUS AN OXYGEN TERM
FED2 - THE FRACTIONAL EFFECTIVE DOSE DUE TO
        CO,CO2,HCN AND O2 BASED ON PURSER'S
        EQUATIONS
FED3 - THE FRACTIONAL EFFECTIVE DOSE DUE TO
        CO2 BASED ON PURSER'S EQUATIONS
TEMP1 - THE AVERAGE TEMPERATURE OF THE
        LAYER OF THE ROOM TO WHICH THE
        PERSON IS EXPOSED - IT IS THE
        SAME AS TEMP USED IN THE HAZARD I TENAB
TEMP2 - THE FRACTIONAL EFFECTIVE DOSE DUE TO
        CONVECTIVE HEAT BASED ON PURSER'S
        EQUATIONS

* IF PERSON IS WAITING AT A WINDOW, HE IS CONSIDERED TO BE
AT THE NODE (ROOM) FROM WHICH HE CAME PRIOR TO REACHING THE WINDOW
THIS ALLOWS HIM TO CONTINUE TO BE EXPOSED TO THE ROOM FIRE CONDITIONS

Like EXITT, the output from TENAB is divided into a number of sections. The first several sections simply reproduces the data calculated by EXITT. The remaining sections show the results of the calculation, grouped to show the effects for each occupant. At each time interval, TENAB determines for each occupant of the building the current room being occupied and the layer to which the occupant is exposed. From this information, the average layer temperature of the room, the fractional exposure doses, the flux and integrated concentration-time product are computed. If the FED, FEDP, FEDCO2, FEDTEMP, TEMPA, or CT for a particular occupant exceeds the "critical" incapacitation level, or if the FLUX exceeds the corresponding tenability limit then the occupant is considered incapacitated. If the FED, TEMP or CT for a particular occupant exceeds the "critical" lethality level, then the occupant is considered dead. When an occupant exits the building, reaches a window, becomes incapacitated or dies, the program records the time, the room, the occupant's condition, the cause, and the levels of FED, FEDP, FEDCO2, FEDTEMP, TEMPA, CT, and FLUX. The meaning and limits for each of these criteria are described in section 6 and 7 of the Technical Reference Guide.

4.9.6 The TENAB Dump File

After entering the output file name, the user will be prompted for the TENAB dump file name. The TENAB dump file name can be any valid file name, provided the file does not already exist, but cannot be a device name other than NUL. In the case the file already exists and was not given the same name as a file currently being used by TENAB, the user may select to overwrite the file or reenter a different name. The TENAB dump file will contain the tenability measures for each person as a function of time and its primary purpose is to serve as an input file to FASTplot, a plotting program, so that the tenability measures can be plotted.

5 Error Messages

5.1 EXITT Runtime Errors

*** ERROR: Bad room height line in BUILDING / OCCUPANT file
Program stopped

> *The line of the building / occupant file which specifies the floor height could not be read correctly. Typically, either a line is out of sequence in the file or the line contains non-numeric data.*

*** ERROR: Bad floor elevation line in BUILDING / OCCUPANT file
Program stopped

> *The line of the building / occupant file which specifies the floor elevation could not be read correctly. Typically, either a line is out of sequence in the file or the line contains non-numeric data.*

*** ERROR: BUILDING/OCCUPANT and FAST files disagree on the number of rooms
Program stopped

> *The number of rooms is specified in the building / occupant file and is checked against the data in the FAST dump file. The two numbers must agree.*

*** ERROR: Cannot have an EXITT room number be a door or window node number
Program stopped

> *EXITT room numbers must be assigned only to interior nodes.*

*** ERROR: Cannot group nodes to a room number outside of 1-N
             Program stopped

             *For rescue or notification in EXITT, nodes are grouped into
             sets representing individual rooms within the building. The
             groups of nodes must be assigned a number corresponding to
             one of the existing nodes. N will be defined when the program
             gives the error message.*

*** ERROR: Cannot start a person at door or window
             Invalid node assignment
             Program stopped

             *Since the evacuation process takes a person from their
             beginning location to the nearest accessible door or window,
             starting at a window or a door is pointless and is not allowed
             in the model.*

*** ERROR: Distance between nodes must be non-negative
             Program stopped

             *Every pair of adjacent nodes in the EXITT mapping is as-
             signed a travel distance which is the walking distance between
             the nodes. Obviously, this quantity must be greater than zero.*

*** ERROR: Dump file from version Y
             Expecting version X
             Program stopped

             *Exitt program requires a FAST version X dump file in order to
             read the file. The programs supplied with HAZARD I are
             compatible.*

*** ERROR: Error or End of file encountered in BUILDING / OCCU-
PANT File
Program stopped

> *Data could not be read from the building / occupant file.
> Either invalid data in the file (e.g., character instead of
> numeric data) or an incomplete BUILDING/OCCUPANT file
> can cause this message.*

*** ERROR: File already exists

> *Can occur when trying to create an output file. In order to
> not overwrite an existing file the user is warned and allowed
> an opportunity to select another file name.*

*** ERROR: File cannot be CON

> *The device CON (PC keyboard for input and screen for output)
> cannot be used as the input / output file in this instance.
> Some of the files read by EXITT are specially formatted files
> which can only be read or created by the modules of HAZ-
> ARD I. It is not possible to type them in from the keyboard or
> view them intelligibly on the screen.*

*** ERROR: File cannot be inquired

> *Before overwriting output files, EXITT will check to see if the
> file exists. If an error occurs trying to make this determi-
> nation, you will be asked to enter another file name.*

*** ERROR: File cannot be NUL

> *The device NUL (a scratch file that is deleted after program
> execution) cannot be used as the input/output file.*

*** ERROR: File cannot be PRN

> *The device PRN (printer) cannot be used as the input / output file.)*

*** ERROR: File does not exist or is not local

> *Can occur when trying to open an input file. If the file does not exist or is not in the current directory (when no path name given) there will be no data to read.*

*** ERROR: File is already opened

> *The file is already being used by the program.*

*** ERROR: File is not formatted

> *The file is not formatted but is expected to be formatted. Some of the files read by EXITT are specially formatted files which can only be read or created by the modules of HAZARD I. Trying to use one of these files for a normal text file will result in this message.*

*** ERROR: File is not sequential

> *The file is not sequential but is expected to be sequential. Some of the files read by EXITT are specially formatted files which can only be read or created by the modules of HAZARD I. Trying to use one of these files for a normal text file will result in this message.*

*** ERROR: Input file cannot be NUL

> *The device NUL (a scratch file) cannot be used as an input file.*

*** ERROR: Input file cannot be PRN

The device PRN (printer) cannot be used as an input file.

*** ERROR: Invalid action indicator - Must be a 0 or a 1
Program stopped

In BUILDING/OCCUPANT file, the occupant section, the action indicator line contained an entry which was not 0 or 1. A value of zero indicates the occupant can escape unaided or a 1 if the occupant requires assistance to exit the building. No other numbers are allowed.

*** ERROR: Invalid age - Must be between 0 and 120
Program stopped

In BUILDING/OCCUPANT file, the occupant section, an occupant's age was not between 0 and 120.

*** ERROR: Invalid detector location
Program stopped

In BUILDING/OCCUPANT file, the building section, the detector was specified as being at an invalid node number or at a door or window node number.

*** ERROR: Invalid edge node
Program stopped

In BUILDING/OCCUPANT file, the building section, an invalid node number was given.

*** ERROR: Invalid file name FNAME

The file name, FNAME, is not a valid file name. You will be asked to enter another file name.

*** ERROR: Invalid mapping between EXITT nodes and FAST room numbers
Program stopped

The entries on the two lines of the BUILDING/OCCUPANT file are incorrect. An EXITT node may be assigned to more than one FAST room or an invalid number may have been entered for a FAST room or on EXITT node.

*** ERROR: Invalid node assignment - must be between 1 and N
Program stopped

N will be given the appropriate value which is the number of nodes specified in the BUILDING/OCCUPANT file.

*** ERROR: Invalid sex indicator - Must be a 0 or a 1
Program stopped

In BUILDING/OCCUPANT file, the occupant section, the sex indicator line contains an entry which is not a 0 or a 1. An entry of zero indicates a female and a one indicates a male. No other numbers are allowed.

*** ERROR: Invalid sleep indicator - Must be a 0 or a 1
Program stopped

In BUILDING/OCCUPANT file, the occupant section, the sleep indicator line contains an entry which is not a 0 or a 1. A zero indicates the occupant is asleep and a one indicates the occupant is awake.

*** ERROR: Invalid sleep penalty - Must be between -15 and 50
                    Program stopped

                    In BUILDING/OCCUPANT file, the occupant section, the sleep penalty indicator line contains an entry outside the range of -15 to 50.

*** ERROR: Last time of fname1.dmp was K seconds
                    First time of fname2.dmp was N seconds
                    The two files do not follow each other
                    Program stopped

                    When two or more FAST dump files are used sequentially, the last time of the previous file is expected to be the same as the first time of the next file.

*** ERROR: Must have at least N-1 edges
                    Program stopped

                    In BUILDING/OCCUPANT file, the building section, the minimum number of edges must be greater than or equal to the number of nodes-1.

*** ERROR: Noise level must be non-negative
                    Program stopped

                    In BUILDING/OCCUPANT file, the building section, the node noise level was given a negative value.

*** ERROR: Number of people must be between 1 and 10
                    Program stopped

                    In BUILDING/OCCUPANT file, the occupant section, the number of occupants was given as less than 1 or greater than 10.

*** ERROR: Number of smoke detectors must be between 0 and 10
                          Program stopped

                *In BUILDING/OCCUPANT file, the building section, the
                number of smoke detectors was given as greater than 10.*

*** ERROR: Number of rooms must be between 1 and 10
                          Program stopped

*** ERROR: Room alarm noise level must be non-negative
                Program stopped

                *In BUILDING/OCCUPANT file, the building section, a room
                alarm noise level was given a negative value.*

*** ERROR: The nodes are not all connected together.   Node 1 cannot
                reach node I
                Program stopped

                *In BUILDING/OCCUPANT file, the building section, there
                exist nodes from which you cannot reach other nodes.   The
                program expects that any node can be reached from any other
                node through some path.*

*** ERROR: There are no doors or windows
                No one can escape
                Program stopped

                At least one exit must be available.

*** ERROR: Too many dump files - Program stopped
                Allow 10 FAST, 1 BUILDING/OCCUPANT, 1 OUTPUT,
                AND 1 TENAB FILE

*** ERROR: Total number of nodes must be at least N
                Program stopped

Here N will be given as the number of FAST rooms. There must at least as many EXITT nodes as FAST rooms.

*** ERROR: Trouble with FAST dump file
                Program stopped

The first FAST dump file given is not a FAST compatible file. If the first file cannot be read, the program is stopped.

*** ERROR: Trouble with FAST dump file

A subsequent FAST dump file given is not compatible. Further data is simply ignored and data from the files processed up to this point are processed.

*** WARNING: IN RMVBLK, Truncation has occurred removing blanks from:
                         FNAME1
                         FNAME2

Typically occurs when path\filename exceeds 63 characters or an invalid file name has been specified for an input or output file.

*** WARNING: Travel speed of X is excessive

In BUILDING/OCCUPANT file, the occupant section, a travel speed was specified as greater than 5 m/s. The message is just a warning and the value will still be accepted and used.

5.2 FAST Runtime Errors

A pointer to a compartment must be a number
Non numeric Token for display pointer
A layer must be specified
Invalid string for Palette label
Non numeric for label color
Invalid label
Invalid first angle
Invalid second angle
Invalid filename for view
Non numeric window entry
Non numeric for graph color
Invalid string for graph title
Over indexing in gas list
Non numeric value for index
Invalid number in loadup

> *An error has been found in reading the graphics specification.*
> *Check the syntax of the specification as detailed in chapter 4.*

*** At least one thermal name is not defined nnnnnnnn ***
QUIT WHILE READING THERMAL DATABASE

*** The name nnnnnnnn does not exist in the thermal database ***

> *One of the materials specified as a ceiling, wall, or floor*
> *material could not be found in the thermal database. All*
> *specified materials must be defined in the thermal database.*
> *The label nnnnnnnn shows the undefined name.*

Display area overwritten

> *An error has occurred preparing the graphical display output. Check the graphics specification for correct syntax as described in chapter 4.*

ERROR IN ACCESSING DUMP FILE, ERR = N
STOP 697

> *(An error has occurred trying to write the model outputs to the dump file. The error code N provides greater detail of the error. Usually, there is insufficient room on the output disk to write the information.*

ERROR OPENING RESTART FILE

> *The file specified by the RESTRT key word could not be read or is not a valid FAST dump file.*

EXCEEDED ARRAY BOUNDS FOR GRAPHS

> *An error has occurred preparing the graphical display output. Check the graphics specification for correct syntax as described in chapter 4.*

FILE NOT FAST COMPATIBLE

> *The first line of the input file does not specify a FAST version 18 input.*

Illegal device for graphics output

> *Only device number 4 (for screen output) or number 6 (for HPGL output) may be specified in a graphics specification. No other numbers may be entered.*

NOT AN ALLOWED FIRE TYPE

Only fire types 1 (for an unconstrained fire) or 2 (for a constrained fire) are allowed. No other numbers may be entered.

STOP 69

An internal error has occurred in the differential equation solver. This error should never occur. If it does, notify NIST and have available the model inputs.

**** WARNING - MISMATCH IN DUMP FILE SPECIFICATION

A dump file name has been found with a DUMPR keyword specification but no dump file was specified on the files line of the input. No dump file output will be generated.

**** WARNING - EXCEEDED MAXIMUM DUMP INTERVALS

A maximum of 50 dump intervals are allowed. If more are specified, the dump interval is adjusted to produce a total of 50 dump intervals.

5.3 FASTplot Runtime Errors

List is empty; need variables before obtaining their values.
Must create a list before plotting graphs.
No data to save!
No variables to read
No variables to duplicate.
No list to duplicate
No variables on the list.

Nothing to plot

> *The working list of variable is empty. You must use the FILE command and the ADD command to read data from a FAST or TENAB input file prior to plotting, listing, or saving data.*

Duplicate of list will exceed allowable size.
Too many variables - RAPID list reduced.
Too many variables - TENAB list reduced.
Variable list is full. No more additions allowed.

> *A total of 25 variables may be on the working list at one time. Use the CLEAR command and read in the additional data to create separate graphs.*

No file open for reading.
A FILE command must be executed prior to the ADD command

> *Prior to reading data in from a FAST dump file, the name of the file must be specified with the FILE command.*

Error opening RAPID dump file, error = n
Error opening TENAB dump file, error = n
Error in opening FAST dump file n, File =

> *An error has occurred trying to read an input data file. The error number n gives more detail. Usually, the specified file is not in the proper format for reading. Some of the files read or written by FASTplot are specially formatted files which can only be read or created by the modules of HAZARD I.*

No new variables were added.
Time channel not found.
None of the selected channels were found.

Information not found.

> *The information you selected to read from the input file could not be located in the file. Check the input file and try again.*

Parenthesis Error, Check Input!
The plot descriptor contains an error.
Variable numbers must be from 1 to

> *The plot command specifying the variable to be plotted contained an error. Usually either a missing parenthesis or an invalid variable number results in these errors.*

All variables must be from the same file.

> *Data to be saved with the save command must have originated in the same type of file - a FAST file, a TENAB file or an ASCII text file.*

Error in opening new file.

> *The file name specified for a SAVE could not be opened. Either the file name was typed incorrectly or the disk file already exists.*

Units do not match, try again.

> *On a single graph, the physical units of the curves must be the same. Temperature cannot be plotted on the same graph with interface height, for instance.*

Compartment number must be between 1 and n

> (The number of rooms in a FAST dump file
> is determined automatically from the file.

Only numbers corresponding to a valid room
may be entered.)

n Is not on the current list of species

> *FAST models a limited set of species production rates. The
> key word entered for a species is not one modelled by FAST.*

On the list already!
That ventflow on list already, try again.

> *FASTplot checks to make sure only one copy of a single
> variable is maintained on the working list of variables.*

Syntax error in option, try again.
Possible Variable Match, More Characters Are
Required, Try Again.
Syntax error in variable input.

> *An error was found on the ADD command. Additional
> variables are ignored. You may reenter the additional vari-
> ables with another add command or read in the data up to the
> invalid entry by issuing a READ command.*

5.4 TENAB Runtime Errors

*** ERROR: Bad input line - Please try again

> *The line could not be read. You are allowed to reenter the
> line. The prompt for the line should tell you what information
> should be entered.*

*** ERROR: Cannot have more than 10 people - new person ignored

A maximum of 10 people can be simulated in a single execution of TENAB.

*** ERROR: Error in reading EXITT file
Program stopped

*** ERROR: Error in reading EXITT file in section relating EXITT nodes with FAST rooms
Program stopped

The specified EXITT dump file could not be read.   Typically, the wrong name was specified for the file.)

*** *ERROR:*   *Expecting a data file produced by EXITT version X*
EXITT dump file is from version Y
Program stopped

(TENAB and EXITT versions must be compatible.   The versions supplied with HAZARD I are compatible.

*** ERROR: FAST Version: X
TENAB Version: Y-Creation Date:mm/dd/yy
                        - Run Date: mm/dd/yy
Incompatible versions
Program stopped

TENAB and FAST versions must be compatible.   When the FAST dump file is created by version X of FAST and the TENAB version is Y, TENAB will not be able to read the dump file.

*** ERROR: File already exists

> *Can occur when trying to create an output file.   In order to not overwrite an existing file the user is warned and allowed an opportunity to select another file name.*

*** ERROR: File cannot be CON

> *The device CON (PC keyboard for input and screen for output) cannot be used as the input / output file.*

*** ERROR: File cannot be inquired

> *Before overwriting output files, TENAB will check to see if the file exists.   If an error occurs trying to make this determination, you will be asked to enter another file name.*

*** ERROR: File cannot be NUL

> *The device NUL (a scratch file that is deleted after program execution) cannot be used as the input/output file.*

*** ERROR: File cannot be PRN

> *The device PRN (printer) cannot be used as the input / output file.*

*** ERROR: File does not exist or is not local

> *Can occur when trying to open an input file.   The file does not exist or is not in the current directory (when no path name given).*

*** ERROR: File entered for EXITT file is not an EXITT file
Program stopped

> *An EXITT file created by EXITT will have an identifier line which the TENAB program checks. Typically, a wrong file name has been specified.*

*** ERROR: File is already opened

> *The file is already being used by TENAB for another purpose.*

*** ERROR: File is not formatted

> *The file is not formatted but is expected to be formatted. Some of the files read by EXITT are specially formatted files which can only be read or created by the modules of HAZARD I. Trying to use one of these files for a normal text file will result in this message.*

*** ERROR: File is not sequential

> *The file is not sequential but is expected to be sequential. Some of the files read by EXITT are specially formatted files which can only be read or created by the modules of HAZARD I. Trying to use one of these files for a normal text file will result in this message.)*

*** ERROR: *In FAST dump file FNAME*

> *(File empty, error on read, or wrong version of dump file.*

*** ERROR: Input file cannot be NUL

> *The device NUL (a scratch file that is deleted after program execution) cannot be used as the input file.*

*** ERROR: Input file cannot be PRN

The device PRN (printer) cannot be used as the input file.

*** ERROR: Invalid critical values - entries must be floating point numbers

When user supplied values are used to override the default values for tenability limits, the values for incapacitation and lethality must be entered as real numbers with decimal points.

*** ERROR: Invalid file name FNAME

The file name FNAME is not a valid path\name.

*** ERROR: Last time of FNAME1.DMP was X seconds
              First time of FNAME2.DMP was Y seconds
              The 2 files do not follow each other
              Program stopped

Can occur when using more than one FAST dump file in sequence. TENAB expects that the last time of the previous file be the first time of the next file. If not, then the files are considered not to be in sequence.

*** ERROR: No people in EXITT data or trouble reading input file

(The output file from EXITT does not con-
tain any information on the egress of people
from the building. Check your input and
printed output from the EXITT run to insure
the correct simulation.)

*** ERROR: No people were entered from EXITT

*** ERROR: Node numbers must be between 1 and N
Please try again

N is the number of nodes in the EXITT file.

*** ERROR: Node numbers must be between 1 and N
Program stopped

N is the number of nodes in the EXITT file.

*** ERROR: Number of nodes cannot exceed 100
Program stopped

*** ERROR: Room number out of range in section relating EXITT nodes
with FAST rooms in EXITT file
Program stopped

*An EXITT node was mapped onto a nonexistent FAST room
number.*

*** ERROR: Time must be > = 0 seconds
Program stopped

The enter time must be non-negative.

*** ERROR: Cannot have more than 10 distinct occupants so occupant K
cannot be entered

*** ERROR: TENAB dump file cannot be CON

*The device CON (keyboard for input and screen for output)
cannot be used as the output file. Some of the files read or
written by TENAB are specially formatted files which can only
be read or created by the modules of HAZARD I.*

*** ERROR: TENAB dump file cannot be NUL

The device NUL (a scratch file that is deleted after program execution) cannot be used as the input file. Some of the files read or written by TENAB are specially formatted files which can only be read or created by the modules of HAZARD I.

*** ERROR: TENAB dump file cannot be PRN

The device PRN (printer) cannot be used as the output file. Some of the files read or written by TENAB are specially formatted files which can only be read or created by the modules of HAZARD I.

*** ERROR: Time must be $> = 0$ seconds - Please try again

*** ERROR: Too many dump files 10 FAST, 1 EXITT, 1 OUTPUT and 1 TENAB file allowed
Program stopped

*** WARNING: IN RMVBLK, Truncation has occurred removing blanks from:
FNAME1
FNAME2

Typically occurs when path\filename exceeds 63 characters or an invalid file name has been specified for an input or output file.

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7 Index

Appendix A. Worksheets

Building Node Worksheet

BLD File Name: _____

FAST Rooms: _____   Nodes: _____

Detector Node Number: _____   Activation Time[a]: _____

EXITT Node Number	EXITT Room Number	FAST Room Number[b]	Node Height[c] (m)	Floor Height[d] (m)	Ambient Noise[d]	Detector Loudness[d]

a - enter -1 for program to determine detector activation time.

b - enter the FAST room number if not a door or window,

    # of FAST room + 1 if node is a door,

    # of FAST room + 2 if node is a window.

c - enter floor to ceiling height at the node.

d - at the node.

Building Travel Paths Worksheet

Number of Edges: _____

First Node Connected to Edge (must be a node on the Building Node Worksheet)	Second Node Connected to Edge (must be a node on the Building Node Worksheet)	Travel Distance Between Nodes (m)

Building Occupant Worksheet

Number of Occupants: _____

Occupant Number	Age	Sex[a]	Awake or Asleep[b]	Initial Node Location	Assistance required[c]	Sleeping Penalty[d]	Travel Speed[e] (m/s)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
13							
14							
15							

a - use 0 for female and 1 for male.
b - use 0 for asleep and 1 for awake.
c - use 0 if no assistance is required and 1 if assistance is required.
d - acceptable range is -15 to 50.
e - use -1. for default travel speed of 1.3 m/s.

4. TITLE AND SUBTITLE

Software User's Guide for the HAZARD I Fire Hazard Assessment Method, Version 1.1

5. AUTHOR(S)

R. D. Peacock, W. W. Jones, R. W. Bukowski, and C. L. Forney

11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

This report describes a method for predicting the hazards to occupants involved in a building fire. To implement the method, a personal computer software package called HAZARD I is provided. The software consists of modules which can predict the time varying environment within a building resulting from a specified fire; the locations and actions for a specified group of occupants as they interact with the building, the fire, and each other; and the impact of the exposure of each of the occupants to the fire products in terms of whether the occupants successfully escape, are incapacitated, or are killed.

NIST Handbook 146 consists of the *Technical Reference Guide*, the *Software User's Guide*, plus computer software supplied on six 5¼" and three 3½" disks.

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

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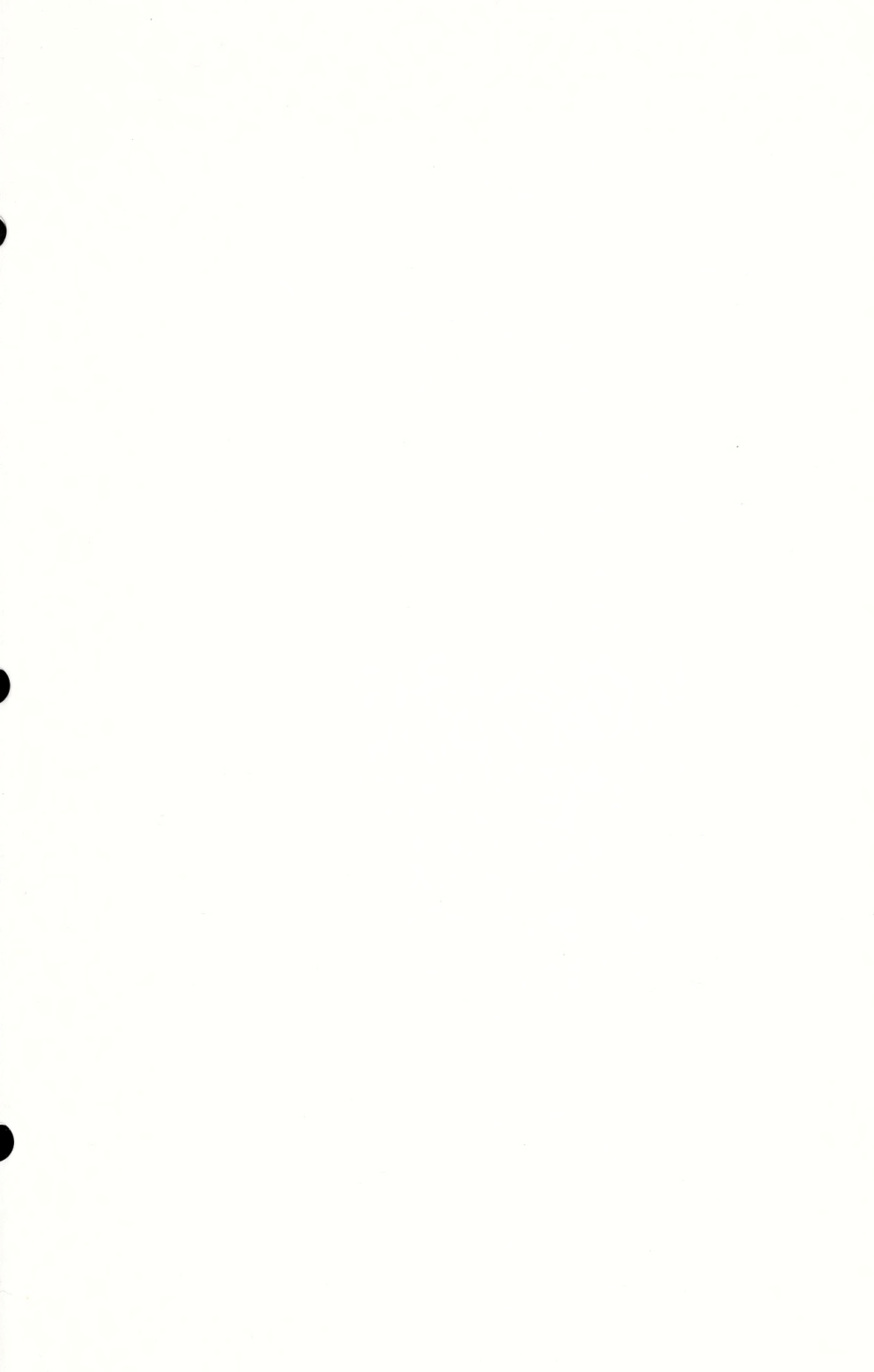
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